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Prevalence of Neck and Back Pain amongst Aircrew at the Extremes of Anthropometric Measurements

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Human Use

Human subjects participated in this study after giving their free and informed voluntary consent. Investigators adhered to Army Regulation 70-25 and USAMRMC Regulation 70-25 on use of volunteers in research.

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14. ABSTRACT

Back and neck pain are a significant cause of morbidity among helicopter aircrew. The majority of studies evaluating the influence of anthropometry are limited to body mass index and stature. Nine anthropometric parameters were measured and a survey was issued to 88 aviators. Weight and neck circumference distribution were skewed to the right and not representative of 98 percentile distributions. Helmet size did not correlate well with reported helmet size. Eighty-two percent of responses reported flying related back pain and the most common complaint was lack of back support in current aircraft configuration. Posture was cited as a contributory factor on 67 percent of all aircrew surveyed, but no one anthropometric measure predicted postural complaints. Aircrew with more flying hours were most likely to report severe back pain. Fifty-eight percent of aviators reported neck pain when flying and individuals with smaller sitting height, fewer flying hours, of heavier NVG counterbalance weight reported less neck pain.

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<u>Executive Summary</u>

Back and neck pain are a significant cause of morbidity among helicopter aircrew. The majority of studies evaluating the influence of anthropometry are limited to body mass index and stature. Posture can contribute to back pain with aircrew adopting a forward-flexed posture reporting more back pain than those in an upright position. Low back pain causes up to 33 percent of all compensation costs in the U.S. and has a lifetime prevalence of 70 percent in industrialized countries. In active duty military intervertebral disc disorders of the back accounted for 6.4 percent of all outpatient consultations. With the use of head-mounted devices, neck pain has become a prevalent condition with up to 57 percent of Swedish aircrew reporting neck pain over a 3-month period.

The investigators measured nine anthropometric parameters (stature, weight, sitting height, functional leg length, buttock-knee length, thigh clearance, thumb tip reach, head circumference, and neck circumference) and issued a neck pain survey to 88 aviators (56 pilots and 31 rear crewmen and 1 not determined). Anthropometric measurements were categorized according to percentiles determined from a 1988 anthropometric survey. The majority of volunteers were in the 50th percentile or higher for weight and neck circumference, likely representing a change in body shape over the last 23 years. Helmet size did not relate well to head circumference demonstrating that more detailed head measurements are required for helmet fitting. Age of volunteers ranged from 19 to 59 years and those older than 45 years all had 2500 or more total flying hours. Volunteers between the ages of 19 to 24 years all had less than 500 flying hours.

Overall discomfort in the aircraft increased as weight and neck circumference increased. Few individuals reported limitations in control movement, but those who reported difficulty reaching the collective were all in the upper quartile for weight and neck circumference. Fifty nine percent of pilots reported that their back was not supported in the flying position but this did not correlate with any specific anthropometric parameter. Rear crewmen in the 4th quartile for functional leg length were more likely to report the need to slouch to fit in the rear cabin. Only 3 out of 27 rear crewmen felt that their back was supported when flying.

Neck pain was prevalent with up to 58 percent of aviators complaining of pain when flying. Neck pain was most common in the 30 to 39 age group with no positive responses in the 19 to 24 age group. A higher proportion of individuals with neck pain related to flying were in the 4th quartile for functional leg length, most rear crewmen were in the 4th quartile for weight. All aircrew older than 55 years reported neck pain during flight. Individuals complaining that adverse posture with night vision goggles (NVG) contributed to neck pain were more likely to have more than 2500 flying hours, more than 750 total NVG hours and be in the 4th quartile for weight or 3rd and 4th quartile for head circumference. Posture without NVG was also considered to be a contributing factor in neck pain after flying. Neck pain after flight was rated as more severe among those in the 3rd and 4th quartiles for sitting height. Aircrew rating their average or worst neck pain as severe were more likely to report an effect on mission-related tasks. Individuals with small sitting height, less than 500 total flying hours or age less than 25 years were less likely to report flying-related neck pain. Average neck pain during flight was rated as less severe by those personnel using heavier NVG counterweight.

Back pain had a high prevalence with 54 percent of aircrew reporting back pain not related to flying and 82 percent of aircrew reporting flying-related back pain. The presence of non-flying related back pain is a major confounding factor when assessing the influence of flying on individual symptoms. Posture was considered to be a contributory factor to back pain during flight in 89 percent of respondents (67 percent of all aircrew surveyed) with similar figures for back pain after flight. Aircrew with 3000 or more flying hours were more likely to report average back pain as severe to incapacitating but, despite the severity of the pain, aircrew with more than 3500 total flying hours did not report an effect of back pain on mission-related tasks, however those with more than 750 total NVG hours were more likely to report back pain affecting the mission. Aircrew with less than 1000 total flying hours were less likely to report back pain after flight and the majority of those with less than 500 total flying hours reporting pain as mild or less.

Both back pain and neck pain were reported as reasons for aircrew grounding with 21 percent reporting a period of grounding for back pain and 6 percent of aircrew for neck pain. Severity of worst back pain had most effect on leisure activity and the most commonly affected activity was sleep, closely followed by physical activities.

In summary, weight and neck circumference distribution was not representative of 1998 percentiles. Back pain was more prevalent among aviators than neck pain. The most common complaint among aviators was lack of back support and contribution of posture to back pain. Individuals with smaller sitting height, fewer flying hours and heavier NVG counterbalance weights reported less neck pain and there is scope for more detailed examination of the influence of sitting height and NVG counterbalance on neck pain.

Quartiles of anthropometric measures are not sensitive enough to be used in evaluation of anthropometric data as risk factors in development of pain. Age and flying hours were the best predictors of pain severity and pain severity was the best predictor of effect on mission-related tasks.

Many aviators were using additional cushions and there is scope to examine different styles of lumbar cushions to see if this improves reports of discomfort, back pain, and the effect on mission-related tasks.

There is scope to repeat the study with a larger subject population to enable more detailed analysis of percentiles, particularly related to sitting height, functional leg length, and weight.

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Introduction

This study was designed to evaluate specific anthropometric parameters as risk factors for neck and back pain amongst aircrew. Both cockpit and cabin space are limited in helicopters, particularly smaller scout helicopters. Anthropometry recommendations exist for each airframe but personnel at or exceeding these recommended limits still operate small helicopters. Few studies exist that evaluate the contribution of size to neck and back symptoms in aircrew. This study measured male pilots and rear crewmen to compare the prevalence of reported neck and back symptoms in upper and lower quartiles with those of average build.

Background

Back pain and neck pain are a significant cause of morbidity among helicopter aircrew. Much work has been done to investigate the influence of posture, head-mounted mass, vibration and G-acceleration on the development of neck and back symptoms, but little is published about the role of body measurements as risk factors for neck and back pain.

Low back pain accounts for up to 33 percent of all compensation claim costs in the U.S. with a lifetime prevalence estimated at nearly 70 percent for industrialized countries (National Institute for Occupational Safety and Health [NIOSH], 1997). In active duty military, intervertebral disc disorders and disorders of the back account for 6.4 percent of all outpatient consultations (Armed Forces Health Surveillance Center, 2010). When examining workers with back pain who had sedentary jobs, the strongest correlation between sitting posture and low back pain was found among helicopter pilots (Lis et al., 2007). In 1984, a survey found that 72.8 percent of aviators experienced back pain during the 2 years preceding the survey and those individuals with persisting pain had more flight hours and time on flight status than those with transient pain (Shanahan, 1984; Shanahan, Mastroianni, and Reading, 1985). This compared with a lifetime incidence of 60 to 80 percent in industrial society and prevalence rarely greater than 35 percent. A more recent survey in the United Kingdom (U.K.) also found high prevalence of low back pain among respondents, 83 percent among Royal Air Force (RAF) helicopter pilots compared with 81 percent of civilian helicopter pilots, suggesting that this complaint continues to be a significant health burden among rotary wing aircrew (Cunningham, Docherty, and Tyler, 2010). Individuals with more flight hours are likely to be older in age. Some studies have found a positive relationship between prevalence of back pain and increasing age, with two studies demonstrating a peak between the ages of 45 to 64 years (Andersson, 1999; Kopec, Sayre, and Esdaile, 2003).

Stature and weight have been suggested as risk factors for back pain in the general population. Previous studies have demonstrated an increase in prevalence of back symptoms with increasing stature quintile (Kuh et al., 1993), with abundant growth in early adolescence in males (Poussa et al. 2005b), and with height in men (Kopec et al., 2003). In comparison, a study of Brazilian truck drivers found no correlation with age, weight or stature and back pain (Andrusaitis, Oliveira, and Filho, 2006), and likewise back pain in Slovenian bus drivers was not related to body build or size (Čelan and Turk, 2005).

With the increased use of head-mounted mass, neck pain has also become a prevalent condition with 57 percent of Swedish aircrew reporting neck pain, 32 percent frequent neck pain, 46 percent back pain, 45 percent thoracic pain and 16 percent shoulder pain over a 3-month period (Ang and Harms-Ringdahl, 2006). Similar figures were seen in Dutch military helicopter pilots with a 43 percent prevalence of self-reported neck pain (20 percent continuous) which compared favorably with the general population which had prevalence of 55 percent neck pain (22 percent continuous)(Van den Oord et al., 2010). The general population is however, not a comparable population to military aircrew due to the robust screening that occurs prior to entry to the military. The Dutch neck pain group experienced high physical fatigue at the end of the day and reported more flying hours in the previous year than those without neck pain. There was not however a correlation with the number of hours of night vision goggle (NVG) use.

The helicopter seating position and control configuration is often implicated in back and neck pain. Aircrew usually adopt an asymmetric posture, resting the right forearm on the right thigh for cyclic stability, the left hand on the collective, with forward flexion and lean slightly to the left, known as the 'helicopter hunch' (Shanahan, 1984). Comparison of posture in aircrew with back pain found that forward flexion sitting posture was most frequently reported during instrument flying and low back pain was reported more frequently among Sea King pilots sitting slightly forward than those sitting up straight (Bridger et al., 2002). A survey carried out among Gazelle helicopter aircrew found a prevalence of backache of 82 percent with taller pilots being worst affected. One possible source of discomfort was found to be the routing of the shoulder harness which caused hunching in taller individuals (Braithwaite and Vrnwy-Jones, 1985).

Electromyographic (EMG) and observational studies have produced variable results with studies finding increased activation of the right side of the body (Vellejo et al., 1998), increase activity in erector spinae when leaning forward (Bowden, 1985), or no influence of posture on muscle activity (De Oliveira, Simpson, and Nadal, 2001). Examination of neck muscle activation suggested that small muscles fatigue more rapidly than large neck muscles (Harrison et al., 2009). A study of patients in the general population with back pain severe enough to merit referral for magnetic resonance imaging found a strong association between tall stature and referral rate (Palmer et al., 2008).

Studies have identified loss of lumbar lordosis as a result of poor seat cushions affecting trunk-thigh angle and resulting in a forward creep of the buttocks away from the seat back (Graham-Cumming, 1998). Lumbar supports have been evaluated as a method of improving posture with as much as 40 percent of rotary aircrew using additional back support when flying, depending on aircraft type flown (Thomae et al., 1998). A survey of pilots issued with lumbar supports found that lumbar supports provided complete relief in 63 percent and marked improvement in 32 percent (Reader, 1985). A further evaluation of naval helicopter pilots found that 34 percent of pilots wore lumbar supports and of these two-thirds indicated that the support relieved pain or improved comfort. There was no significant difference in back pain reported between personnel using versus not using lumbar support (Bridger et al., 2002).

Cockpit ergonomics can significantly affect posture with individuals at extremes of anthropometric measures potentially adopting flexed or extended postures to fit in the cockpit and maintain full control movement. The most important anthropometric measures identified for the HH-60G Pave hawk helicopter flight engineer position were sitting height (vertical distance from sitting surface to top of head), mid shoulder height (sitting surface to point on top of right shoulder midway between neck and tip of right shoulder), popliteal height (vertical distance from floor to underside of thigh directly behind right knee sitting with knees flexed at 90 degrees), buttock-knee (horizontal distance from back of buttocks to most protruding point of the right knee) and foot length when standing (Grant, 2002). It is important to consider not just how a person fits in the cockpit but also how the harness is mounted and routed to provide optimum comfort for a range occupant sizes. Change in individual size can alter the position of the shoulder harness take off point resulting in altered posture when tightly secured. The equipment worn by an individual, including flying clothing, survival vest, helmet, and NVGs is increasing in weight and bulk which can also influence posture within the aircraft. Larger personnel may have difficulty fitting into the designed crew space, particularly when fully equipped, which can promote awkward positions and may lead to neck or back pain. The American population is increasing in size. Aircraft equipment, for example, harnesses and energy attenuators, has a defined upper load limit beyond which performance is not guaranteed. The equipment that an individual wears on their person contributes to loading of these safety systems, with potential to exceed the designed upper load limits.

Current ergonomics assessments use the 1988 National Health and Nutrition Examination Survey III for body measurements (Westar, Inc., 1988). Many of the safety features of current aircraft are developed to accommodate personnel through to the 95^{th} percentile however, most airframes and safety equipment predate 1988 and design is based on the anthropopmetry of U.S. Army aviators in 1970 (Department of the Army, 1989). This study compares a set of nine different anthropometric measures with the prevalence of neck and back pain as well as self-reported change of flying posture among rotary aircrew.

Methods

The study was conducted at the U.S. Army Aeromedical Research Laboratory with the support of Army Aviation units on Fort Rucker, Alabama. The protocol was approved by the U.S. Army Medical Research and Materiel Command (MRMC) Institutional Review Board (IRB). All current Active Duty, Reserve, and National Guard aviators based at Fort Rucker, and operating either in the cockpit (pilots) or cabin (rear crewmen) of any rotary aircraft, were invited to participate. A convenience sample was recruited by means of flyers, unit briefings, and word of mouth.

Volunteers were given a questionnaire comprising four sections (Appendix A). No personally identifiable information was recorded and each participant was allocated a random number between 1 and 200. The first section of the questionnaire requested biographical information including age, gender, exercise routine, length of flying career, aviation role, flying hours, and experience in different aircraft. The second section addressed posture, comfort, control movements, and adaptations to seating area. The third section related to use of head-mounted devices and NVGs. The fourth section explored the prevalence of neck and back pain, detailing frequency of symptoms, severity of pain, relationship to flight activity, and treatment received.

Study technicians were trained in measurement techniques using square and round anthropometers, tape measures, weighing scales, and a wall chart. Each participant had nine anthropometric measurements taken while dressed in shorts and t-shirt in accordance with methods listed in the 1988 anthropometric survey (Westar, Inc., 1988).

Stature was the distance measured, using a square anthropometer, between the standing surface and the top of the head, with the individual erect in the anthropometric standing position. Weight was measured using a calibrated scale with the participant dressed in shorts and a t-shirt. Sitting height was the vertical distance, measured, using a square anthropometer, between the sitting surface and the top of the head with the subject seated erect and the head in the Frankfurt plane. Functional leg length was the straight-line distance between the plane of the bottom of the right foot with the leg extended and the back of the body of a seated subject. The left leg was bent to approximately 90 degrees to enhance stability and the right leg was extended with the foot resting on the base plate of a square anthropometer which was resting on the floor. The anthropometer was aligned with the greater trochanter using a prepositioned landmark. Buttock-knee length was the horizontal distance between a buttock plate at the most posterior point of the buttock, and the anterior point of the right knee with hip and knees flexed to 90 degrees, feet resting on raised foam blocks and arms relaxed in the lap. Thigh clearance was the vertical distance between a sitting surface and the highest point on the top of the right thigh, measured, using a square anthropometer, with thighs parallel to the ground, knees flexed 90 degrees and feet in line with the thighs. Thumb tip reach was the horizontal distance from a back wall to the tip of the right thumb, measured, using a wall scale, with the participant standing erect with feet together and heels on a line marked 20 cm away from the wall. Buttocks and shoulders were held against the back wall and the right arm and hand were stretched forward horizontally against the side wall with palm facing down, thumb extended and remainder of fingers curled into a fist. A block was used to measure the horizontal distance of the tip of the thumb and a mean of three measurements was calculated. Head circumference was taken as the maximum circumference of the head above the supraorbital ridges and ears, measured using a steel tape. Neck circumference was measured at the base of the neck with the participant in the standing position and head in the Frankfurt plane.

Data analysis was performed using the SPSS package version 19. All yes/no/not applicable answers were analyzed using Pearsons chi-squared (χ^2) analysis unless stated otherwise and all linear statistics were analyzed using gamma (γ) statistics.

Results

Data were collected over a 2-week period. Eighty-eight volunteers enrolled in the study. Of these, 85 were male and 3 were female. Due to the small number of females they were removed from subsequent analysis of the data. Of the males, 56 were front seat pilots, 28 were aviators operating in the back of the aircraft, and 1 was not qualified in a flying role. The individual in a non-flying role was excluded. The age ranged from 19 to 59 years (divided into 5-year ranges) with the majority of the population aged between 25 and 39 years. Flying experience ranged from up to 200 hours to more than 5000 hours with the majority of participants having between 1000 and 2500 hours. A copy of the questionnaire can be found at Appendix A and the statistical results, found at Appendix B, are organized in accordance with the layout of the questionnaire.

Age and flying hours

Age was compared with flying hours. Only the relationship between age and total flying hours was significant ($p < .001$), those older than 45 years all had 2500 or more flying hours. Individuals age 19 to 24 years all had less than 500 flying hours. The broadest distribution of flying hours was found in the 30 to 39 age group where total hours ranged from 500 to 5000 hours. Flying hours in last 28 days and NVG hours did not have a significant relationship.

Table 1.
Age and total flying hours of participants.

Age	Flying hours										
	1-500	501-1000	1001-1500	1501-2000	2001-2500	2501-3000	3001-3500	3501-4000	4001-4500	4501-5000	5000+
Not specified	1	0	0	0	0	1	0	0	0	1	0
19-24	5	0	0	0	0	0	0	0	0	0	0
25-29	3	3	5	4	1	0	0	0	0	0	0
30-34	0	3	7	5	5	2	0	1	0	0	0
35-39	0	2	6	6	4	2	2	1	0	1	0
40-44	2	0	0	0	3	0	1	0	0	1	0
45-49	0	0	0	0	0	2	0	1	0	0	0
50-54	0	1	0	0	0	0	0	0	0	0	0
55-59	0	0	0	0	0	0	0	0	0	0	1

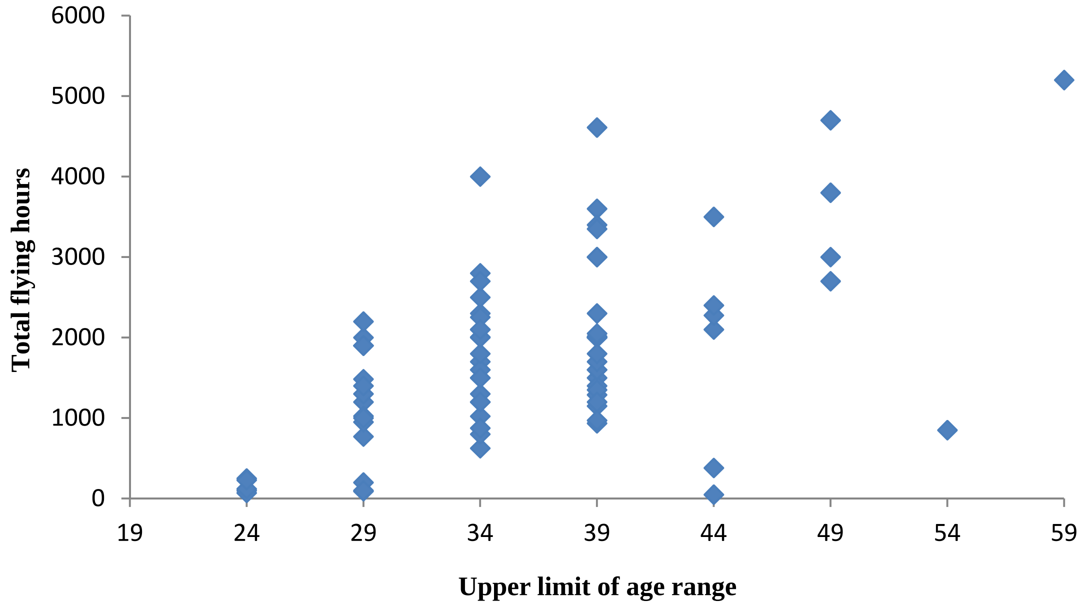
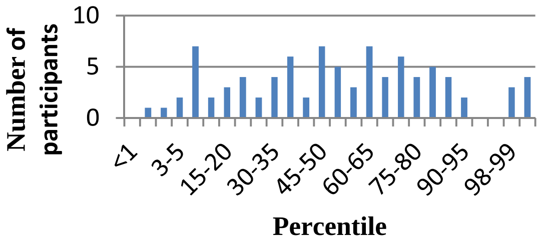


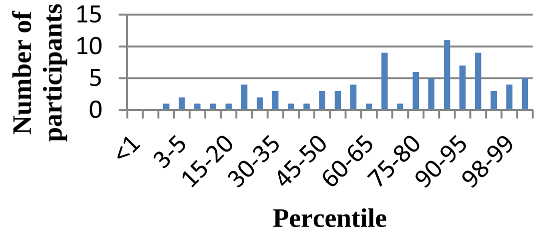
Figure 1: Scatter plot of age and flying hours. Age was reported in 5 year increments and points are plotted at the upper value of those increments, as displayed on the x axis. Actual total flying hours reported is represented on the y axis. One outlier age 50-59 years with more than 12000 flying hours was omitted from the figure.

Anthropometric distribution

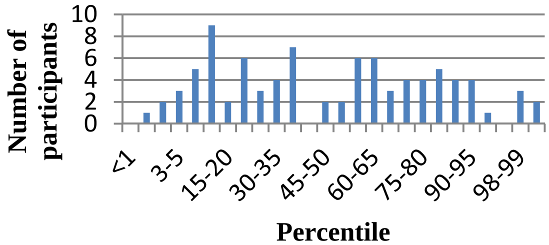
Data were converted into percentiles with reference to the 1988 Anthropometric survey of U.S. Army personnel: pilot summary statistics (Westar, Inc., 1988). Distributions are represented graphically in figures 2 a-i.



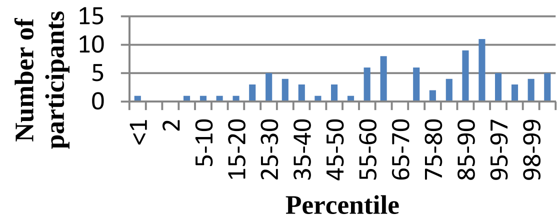
a. Stature



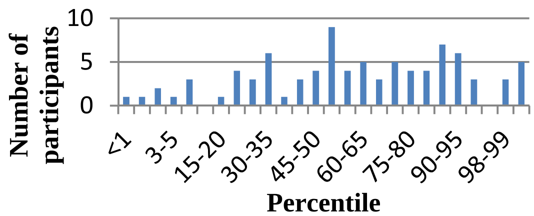
b. Weight



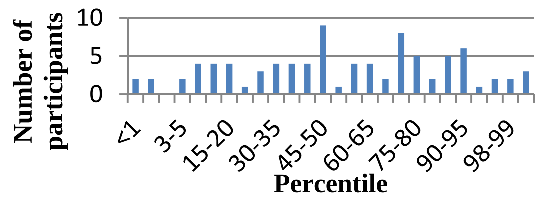
c. Sitting Height



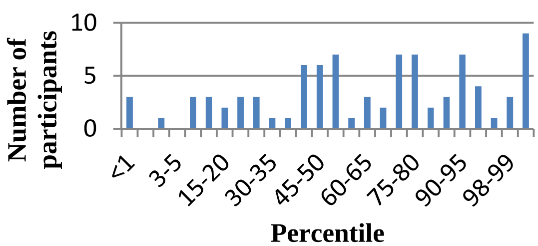
d. Thumb tip reach



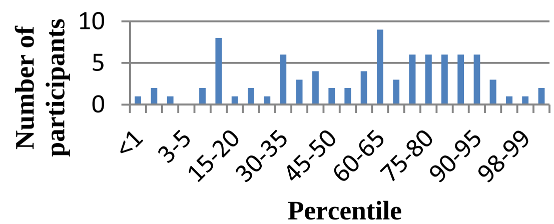
e. Functional leg length



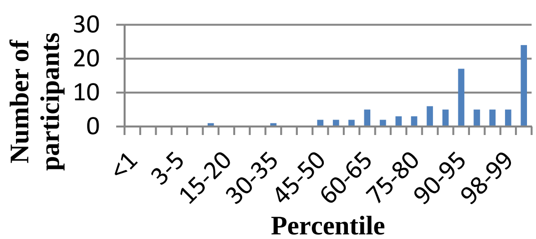
f. Buttock knee length



g. Thigh clearance



h. Head circumference



i. Neck circumference

Figure 2. Distribution of anthropometric percentiles.

Distributions of weight and neck circumference were skewed to the right representing a change in body proportions over the last 23 years. Forty-seven of 49 aviators in the 4th quartile for weight were also in the 4th quartile for neck circumference, compared with 11 of 18 in the 3rd quartile for weight and 7 of 9 in the 2nd quartile, $G = 0.771$, $N = 84$, $p < .001$. Thigh clearance distribution was also significant when compared with weight but the results were more spread across the quartiles. Twenty-eight of 49 aviators in the 4th quartile for weight were also in the 4th quartile for thigh clearance, $G = 0.641$, $N = 84$, $p < .001$. A possible explanation of the increased neck circumference is the increased emphasis on upper body strength training resulting in larger neck musculature. Overall increase in body weight and BMI is likely to also have contributed to neck circumference.

We found that the helmet size did not correlate well with head circumference. The findings are in the table below:

Table 2.
Comparison of head circumference and helmet size.

	Helmet size				
Head circumference quartile	Small	Medium	Large	Extra large	Other/ No answer
1	8	7	0	7	1
2	3	9	4	9	0
3	3	13	6	13	1
4	0	5	18	5	1

Anthropometry and posture in the aircraft

Questions relating to flying control use were divided into pilots and rear crewmen. Volunteers were grouped into quartiles of anthropometric measurements with the first quartile representing individuals in range from less than the 1st to 25th percentiles, second quartile represented the 26th to 50th percentile, third quartile represented the 51st to 75th percentile and fourth quartile represented the 76th to greater than 99th percentile. When the nine separate measurements were compared there was no one value that could be used to group individuals so all anthropometric measures were considered separately.

Some pilots were early in their flying training, with up to 200 flying hours. Some of these had not yet flown with NVG. They were thus excluded from analyses regarding the influence of NVG on posture and neck or back pain.

Pilots only

(1) The reported level of discomfort in the aircraft (54 responses) increased as weight increased, $G = 0.409$, $N = 54$, $p < .001$, also as neck circumference increased, $G = 0.382$, $N = 54$, $p = .013$.

(2) Anthropometric measures were not reliable predictors of headstrike against cabin components either with or without NVG (53 responses). The comments relating to head strike are listed along with each individual sitting height percentile in table 3.

Table 3.
Specific comments relating to head strike in the aircraft cabin.

Airframe	Pilot/ Front seat	Sitting height percentile	Rear cabin	Sitting height percentile
UH-1	lights, sound proof	10-15		
UH-60	Head rest forces me to crane neck forward with NVG battery pack on.	35-40	Roof	98-99
			Roof window seal	15-20
	Depending on where I am looking. To maintain airspace surveillance or view points of reference my head is constantly moving. Circuit breaker panels and side armor protection are in the way.	10-15		
	Weight bag for NVG use hits head brace on seat	25-30		
	Overhead rear circuit breaker panel	90-95		
	Upper door jam when looking to side	3-5		
	UH-60 upper console	70-75		
AH-64	NVG and HMD	90-95		
	SSVs	55-60		

Airframe	Pilot/ Front seat	Sitting height percentile	Rear cabin	Sitting height percentile
CH-47			Cabin door, sound proofing Cabin door Roof The back of the seat, for the head rest, is placed too far forward Top of window Sometimes side windows	>99 10-15 98-99 10-15 55-60 30-35
OH-58	The door frame and the top of the cabin	60-65		
TH-67	MCU hose seat belt guide Battery pack contacts seat back when sitting completely upright Overhead center console TH-67	75-80 35-40 85-90		

(3) Five pilots, from 54 responses, reported mild difficulty reaching the collective and all of these were in the upper quartile for weight, (p = .015) and neck circumference, (p = .023). There were no significant complaints relating to cyclic or pedal reach.

(4) Twenty-one pilots were unable to fully extend their legs but this did not statistically relate to any one anthropometric measurement.

(5) Fifteen pilots reported that their legs struck cockpit components. Details of supporting comments are listed in table 4. No one anthropometric measure was a significant predictor of leg strike.

Table 4.
Details of lower limb strike in the aircraft.

Airframe	Pilot/ Front seat	Rear crewmen/ cabin
UH-1		Bottom of the fuselage
UH-60	Lower display console Knees on center console If older UH-60 with 'short' cockpit lower console can be contacted Cyclic-knees during slopes Collective or cyclic depending on position Lower edge of console	BAPS plating Instrument panel The airframe below the crew windows and more so with armor plates Window sill
AH-64	Lower legs are against MPDs/Instrument panel Left leg with collective/ cyclic hits seat buckle The dash in the front seat (Apache) Bottom of dash with knees	
CH-47	Center console	Instrument panel
OH-58	Dash	
TH-67	Pedals Center console Standby compass	

(6) No pilots reported a need to change posture to reach the pedals.

(7) Nine pilots reported use of cushions to achieve correct sitting position. The only measure that achieved significance was neck circumference with 7 out of 9 pilots being in the 4th quartile for neck circumference (p = .049). This likely reflects the skewed data relating to neck circumference as the majority of volunteers were in the upper 2 quartiles. The cushions used are listed by airframe in table 5.

Table 5.
Use of cushions to achieve correct seating position.

Airframe	Front seat	Rear seat
UH-1		
UH-60	Lumbar support Rolled up towel for lumbar support	Pilot seat cushions
AH-64		
CH-47		Seat pan in crew seat Seat pan Seat pan Seat pan Seat pan
OH-58	In combat seat pads are adjusted Lumbar support	
TH-67	Seat back, and seat pan Personal lumbar back support pillow Lumbar support Lumbar support pillow Lumbar	

(8) Twenty-one pilots reported use of cushions to achieve comfort. Anthropometric measures did not correlate with cushion use in this situation. The comments relating to cushions used are listed by aircraft in table 6.

Table 6.
Use of additional cushions for comfort.

Airframe	Front seat	Rear seat
UH-1		
UH-60	Lumbar support Rolled up towel for lumbar support Seat pan When deployed I used an additional cushion	Seat pan/lumbar support Spares from pilot seats Lumbar
AH-64	Lumbar support Seat pan Oregon Aero AH-64 seat	
CH-47	Seat pan Oregon Aero seat and lumbar Seat and lumbar When authorized (Afghanistan in a CH-47) a partially inflated circular cushion was used to cushion lower spine contact with seat bottom. When deployed flying long missions (6-8 hours) I would use a flight approve 2" Oregon Aero seat cushion with lumbar support I have used lumbar and seat pan cushions in the past; I've also removed the seat back in order to fit with combat gear.	Seat pan in crew seat Seat pan Seat back, lumbar support, seat pan Seat pan Seat pan If available, either seat or back cushion to sit on Seat pan Seat pan
OH-58	In combat seat pads are adjusted Lumbar support seat pan/lumbar support	
TH-67	Lumbar Seat pan Seat	

Airframe	Front seat	Rear seat
	Lumbar support pillow Lumbar	

(9) Thirty-two pilots (59 percent) reported that their back was not fully supported in the flying position. None of the anthopometric measures reached significance. Specific comments and concerns are listed in table 7. Of note is that the majority of comments relate to low back discomfort.

Table 7.
Aviators comments relating to back support in the flying position.

Airframe	Front seat	Rear seat
UH-1	Lower back In a crew seat there is no support Top of back	
UH-60	Lumbar Area Straight back seat. Cushions offer little or no support. Like sitting with my back against a wooden plank. Lower lumbar of back lacks support Lower back Upper back Lower back Lower back Upper back (leaning forward) Lumbar has gap Lumbar Lower back not fully supported Lower and very top Lumbar	Lumbar region Lower back Lumbar Lower back
AH-64	Lumbar (lower back) Upper back not supported due to poor posture 3/4 of the upper back Lower back does not touch seat Upper back due to poor posture for comfort	

Airframe	Front seat	Rear seat
CH-47	Lower back Lumbar Lumbar support is lacking Poor lumbar support	Depending on the crew position in a CH-47 crewmembers back will not be supported at all while looking out the window FE seat doesn't recline Full back Whole back, no effective support for crew members in back seat To properly scan have to sit sideways No being in back of aircraft cannot perform crew duties Lumbar, neck Lower back or entire more or less Middle back feels unsupported Lower and upper back The seat faces directly AFT of the airframe. As a crew chief we need to slouch to see out the side of the aircraft constantly Slouch forward Lumbar crewchief seat/on ramp
OH-58	Lower back Without lumbar inflatable my back would not be fully supported. This is exacerbated greatly with body armor and added M16 clips that is standard practice in theatre	Lower back

Airframe	Front seat	Rear seat
	Lower back	
TH-67	When rotating the seat back, it makes it too low to see over the dash Lower back Lumbar Lower back not supported without lumbar pillow Lower back	
BO6	Lower back Lumbar Lower back	

(10) As head circumference increased, so did the proportion of aircrew reporting mild to moderate difficulty achieving full cyclic control movement (p = .023). No other measure was demonstrated to significantly affect control movements and the contribution of head circumference could not be explained. Details of individual comments are listed by airframe in table 8.

Table 8.
Reported difficulty achieving full range of control movements.

Airframe	Difficulty achieving full range of control movements
UH-1	
UH-60	Clearing aircraft While seat is properly adjusted, I have to stretch or lean to place the collective full down Cyclic on slope operations Cyclic contacts my left leg during slopes and flight control check
AH-64	Must "slouch" to reach cyclic Cyclic hits harness buckle. Knees get numb from not being able to extend them further. The numbness occurs after several hours of flight.
CH-47	Aft cycle typically impacts thighs, but can move full travel with minor movements in the seat
OH-58	Cyclic contact with legs aft left and aft right Not enough room between legs to move cyclic fully without moving them
TH-67	Left cyclic hits left leg Full aft cyclic is sometimes hard to achieve without repositioning Thighs prevent full cyclic movement Full left cyclic and collective raised. Leg is too large.

Rear crewmen only

(1) There was no significant relationship between overall comfort rating and anthropometric measures in rear crewmen. The sample size was only 27 volunteers.

(2) Rear crewmen in the 4th quartile for functional leg length, χ^2 (3,26) = 8.244, p= .041, and 4th quartile for buttock knee length, χ^2 (3,26) = 10.520, p = .015, were more likely to report the need to slouch to fit in the cabin.

(3) The majority of rear crewmen in the 4th quartile for functional leg length, $\chi 2$ (3,28) = 12.080, p= .007, and 4th quartile for buttock knee length, $\chi 2$ (3,28) = 15.469, p = .001, also reported the need to slouch when wearing NVG in the rear cabin.

(4) Anthropometric measures were not a good predictor of headstrike against cabin components among rear crewmen either with or without NVG.

(5) Only 5 out of 27 rear crewmen reported use of additional cushions to achieve correct seating position. Buttock knee length approached significance, $\chi 2$ (6,27) = 12.505, p = .052, and the five individuals were split between the 2nd and 4th quartiles.

(6) Thirteen rear crewmen used cushions for comfort and there was no significant anthropometric measure that could be used to predict the requirement.

(7) Only 3 out of 27 rear crewmen reported that their back was fully supported in the flying position. There was no statistical difference between the quartiles for any of the anthropometric measures.

<u>All volunteers</u>

(1) When all aviators were considered together there was no one measurement that was significant in determination of whether a crew member could comfortably sit upright wearing personal ALSE.

(2) Only neck circumference was significant, G = 0.324, N=83, p = .030, when examining comfort rating and this likely reflects the fact that the majority of personnel were in the 3rd and 4th quartiles.

(3) Individuals reporting slouched posture were more likely to be in the 4th quartile for buttock knee length without NVG, χ^2 (3,82) = 10.330, p = .016 and with NVG, χ^2 (3,82) = 10.263, p = 0.016.

(4) The highest proportion of individuals reporting headstrike against cabin components were in 1st (3/7) and 4th (5/31) quartiles for functional leg length, χ^2 (6,83) = 13.328, p = 0.038.

(5) Twelve of the 14 personnel using cushions to improve reach were in the 4th quartile for neck circumference, χ^2 (6,80) = 80.97, p = .044, however as discussed earlier the population was skewed towards the 3rd and 4th quartiles for neck circumference.

Anthropometry and neck pain

<u>Neck pain unrelated to flying</u>

(1) Twenty-eight of 79 respondents reported neck pain unrelated to flying. Individuals in the 4th quartile for functional leg length had the highest proportion of neck pain unrelated to flying, χ^2 (3,79) = 13.948, p = .003. No other anthropometric measures achieved significance. Details of causes identified by individual volunteers are listed in table 9.

Table 9.
Suggested causation of non flying-related neck pain.

Suggested causation	Detailed description
Sport and PT	Physical exercise, soccer
	Due to sports activities
	Running or heavy lifting caused by lower back pain
	Physical training related issues caused back and neck strain
	Physical exercise
	Injury during pt
	Bad posture, snowboarding, mountain biking, weight lifting, football, being tackled wrestling
Lifting	Heavy equipment lifting maintenance tools
Parachuting	Whiplash--Hard opening--Parachute
	Car accident, pull-ups = neck pain Long duration of flight = back pain
Accident	Accident, discomfort
	Motorcycle injuries
	Fell of aft pylon of CH-47
	Post IED, muscle strain
Military duty and training	Military vehicles as a passenger; NVG use since 1993
	Soreness due to overwork (road marching, dismounted, patrolling etc.)
	10 years Infantry, Airborne, Air assault, M966 accidents
Yard work	Stiff and back when working in the yard
Posture and sleep	I'm a sloucher when sitting and bad sleeping habits; experience tightness and lack of mobility in full range motion
Sleep	Sleeping wrong- stiff Body armor- muscle fatigue- stiff
	Neck- slept wrong, back lifted improperly, turned or twisted while working
	Neck mattress, not enough support
Unknown	Unknown/ maybe pulled muscle/ strain
	Spontaneous onset, pain and spasm
	Discomfort neck back

Neck pain related to flying

(1) Forty-four out of 77 aviators reported neck pain related to flying. Individuals under 24 years of age did not report any neck pain related to flying and the majority of positive responses were in the 30 to 39 age group, $G = 0.328$, N=77,p=.042. A higher proportion of subjects were in 4th quartile for functional leg length, χ^2 (3,77) = 9.285, p = .026. Twenty-six out of 50 pilots who responded reported neck pain related to flying and no one anthropometric measure was significant in this group. A higher proportion of the twenty-five rear crewmen were in the 4th quartile for weight (15/17 responded positively), (χ^2 (3,25) = 7.931 p= .047. The majority of negative responses occurred in those with smallest sitting height, (χ^2 (3,25) = 7.920, p= .048). The majority of respondents with more than 500 hours flying reported neck pain related to flying, the group with less than 500 hours reported no flying-related neck pain, (G = 0.433, N =74, p = .002) and this reflects the positive responses in the older aviators. Details of aviator's comments regarding neck pain related to flying are listed in table 10.

Table 10.
Aviators' comments regarding causation of neck pain related to flying.

Suggested causation	Detailed descriptions
Posture	Posture related IOT see outside aircraft
	Sitting in cabin upright with no support
	Pain while just sitting during and after flight
	Neck pain associated with slouching during NVG use
	NVGs and NVG headrest causes necessity to crank neck
Injury	Neck: Compressed disk due to hard landing. Neck traction helps
	Goggles cause neck pain
Body Armor/ ALSE gear	ALSE gear and seats
Prolonged flight duration	After hours of flying
	After long flights 3 hours or more
	Long hours (> 6 hours) cause strain on neck and back
	8 hours in the cockpit
	Longevity of flight causes discomfort, demanding modes
	Sore neck after a long flight
	During long flights with both systems in combat
Night vision goggles/ long NVG flights	Wearing goggles
	Goggles cause neck pain
	Neck: lengthy NVG flights
	Long NVG flights
	Long flights-- neck pain due to NVG and weight
	NVG/HUD use up to 6 hour flights
	Flying NVGa and HUD several days in a row causes neck to hurt
	NVG flights
	Neck-strain from goggles.

Suggested causation	Detailed descriptions
	Ongoing visits to chiropractor NVG wear, seating position in UH-60
	Long goggle flights
	NVG weight- neck sore.
	Long hours in poorly designed seats; helmet/ NVGs and hours of manipulating control display units in glass cockpits
	Repetitive use
Poor ramp seating	Sitting on ramp and seat in cabin of CH-47
	Calling slingloads, riding ramp w/o seat, crew member seat
Loading cargo	Pushing cargo
	Loading/ unloading cargo
Unspecified	Strain neck, pinch nerve lower back, strain and pull muscle lower back
	Limited mobility in neck
	Both lower and upper back pain during 15 month deployment
	Numbness in hands and feet
	I assume it is from flying, my symptoms have been intermittent lower back pain. I have also had severe pain in my upper back extending from the spinal cord to my right elbow. This pain lasted 1 month and was 2 months prior to this survey.
	Neck strain, pinched nerve, lower back tightness
	Lower back and neck
	Neck pain stiff neck
	Lower and upper back/neck

(2) Forty-five out of 78 aviators complained of neck pain during flight. Age was a significant factor with respondents younger than 25 years reporting no neck pain during flying, respondents older than 55 all reporting neck pain during flying, $G = 0.412$, N=78, p= .008 and the largest proportion of aircrew with neck pain during flying were in the 30 to 39 age group. None of the respondents with less than 500 hours total flying complained of neck pain during flight, all but 1 respondent with more than 3000 hours total flying reported neck pain during flying, G=0.512, $N = 75$, $p < .001$ and those with less than 500 hours flying with NVG were less likely to report neck pain, G=0.391, N=69, $p = .014$. Sitting height was significant only when non-respondents were removed from the analysis, with more neck pain reported in the 2nd quartile, $\chi^2\,(3,78) = 7.865$, $p = .049$. Twenty-six out of 52 pilots reported neck pain during flight; 18 out of 24 rear crewmen reported neck pain during flight and positive responses were not significantly related to any anthropometric measure in either group. There was one positive response in an individual who did not specify his position in the aircraft.

(3) Forty-nine individuals reported the number of episodes of neck pain during flight. Of these there were 29 pilot responses with the highest number of episodes occurring in the 2nd quartile for buttock knee length, $G = -0.490$, $N = 29$, $p = .004$ and the 1st quartile for thigh clearance, $G = .399$, $N = 29$, $p = .035$. No other measures were significant for pilots or for the 19 rear crewmen who responded.

(4) When considering individual in-flight contributory factors, there were 55 responses regarding contribution of low G without NVG (low G was defined as routine flight and less than 2G); 17 participants reported that low G without NVG was a factor (10 pilots, 7 rear crewmen), 21 reported that it was not a factor (13 pilots, 8 rear crewmen), 17 stated not applicable (11 pilots, 6 rear crewmen) and 29 did not respond. Of the positive responses a higher proportion were in the 1st and 2nd quartiles for functional leg length, χ^2 (6,55) = 13.910, p = .031. Rear crewmen in the 4th quartile for thigh clearance had lower proportion of positive responses, χ^2 (6,21) = 14.711, p = .023. Those respondents with more than 2500 flying hours were more likely to consider low G without NVG a factor in flight related neck pain, G = 0.368, N=55, p=.007.

(5) No anthropometric measures were significant when considering contribution of low G with NVG to neck pain during flight. Nineteen pilots and 12 rear crewmen gave positive responses, 9 pilots and 14 rear crewmen stated that the question was not applicable. Individuals reporting more than 3000 hours total flying all reported low G with NVG as a contributing factor to neck pain during flight, G = .530, N = 54, p < .001. The majority of those who did not consider low G with NVG a factor had 1000 total NVG hours G = .366, N=51,p = .039.

(6) There were 49 responses to the question relating to contribution of moderate G (2 to 4G) without NVG to neck pain during flight. Of 11 positive responses 6 were pilots and 5 were rear crewmen. There were no positive responses in the 4th quartile group for sitting height, χ^2 (6,49) = 16.338, p = .012 with most positive responses being in the middle quartiles. No other parameter was significant for moderate G during flight in either pilots or rear crewmen.

(7) When considering the influence of moderate G with NVG during flight there were 51 responses overall with 22 indicating that it was a factor (11 pilots, 10 rear crewmen). Overall the highest proportion of positive responses were in the 3rd quartile for sitting height where 8 out of 12 respondents reported moderate G with NVG as a contributor for neck pain, χ^2 (6,51) = 14.291, p = .027. The majority of positive responses among the 20 rear crewmen were in the 1st and 2nd quartiles for stature, χ^2 (6, 20) = 14.200, p = .027. Remaining anthropometric measures, age and flying hours were not significant.

(8) Posture without NVG was not considered a significant contributor to neck pain during flight when compared with anthropometric measurements. There were 29 positive responses (13 pilots, 16 rear crewmen). Only 10 respondents said posture without NVG was not a contributory factor to neck pain and these all had 3000 hours total flying or less G = 0.454, N = 53, p = .001, i.e., all respondents with more than 3000 flying hours considered posture to be a contributory factor to neck pain during flying without NVG G = 0.454, N = 53, p = .001.

(9) Flying hours was also a significant factor in contribution of posture with NVG to neck pain during flight. There were 37 positive responses (19 pilots, 18 rear crewmen). A high proportion of rear crewmen complaining of postural neck pain with NVG were in the 4th quartile for weight, χ^2, (6,23) = 14.439, p = .025 and 3rd and 4th quartile for head circumference, χ^2 (6,23) = 13.133, p =.041. All personnel who reported that posture did not contribute to neck pain during flight with NVG, or that posture was not applicable, had less than 2500 total flying hours, G = 0.576, N=55, p < .001). Similarly all those who reported no contribution of posture had less than 750 total NVG hours, G = 0.510, N = 51, p = .005, (and 7 of 9 who stated not applicable).

(10) Four aircrew believed that the factors listed in table 11 contributed to their neck pain during flight.

Table 11.
Additional contributory factors to neck pain during flight.

Category of aircrew	Contributing factor
TH-67 pilot	Clearing the aircraft after having neck pain
UH-60 pilot	Body armor
CH-47 pilot	Utilizing CDU of glass cockpits
TH-67 pilot	Extended flight with goggles.

(11) Analyses of the 46 responses to questions related to duration of neck pain following flight without NVG and 53 responses with NVG did not yield any statistical significance of anthropometric measures or flying hours.

Neck pain after flying

(1) Seventy-five volunteers answered the question related to neck pain after flying. Of these 38 complained of neck pain after flying. There was no significant demarcation between anthropometric measures, crew position or age. Aircrew with less than 1000 total flying hours were least likely to report neck pain after flight, $G = 0.406$, $N = 72$, $p = .004$.

(2) Fewer volunteers quantified the number of episodes of neck pain after flying. Of the 47 responses, number of episodes could not be predicted by age, crew position, or anthropometric measures. The highest proportion of personnel with more than 10 episodes (12 out of 15 respondents) reported 11-20 flying hours in the last 28 days, $G = -0.359$, $N = 46$, $p = .034$. The majority of respondents with more than 10 episodes of neck pain after flying had less than 15 hours NVG flying in the preceding 28 days, $G = -0.338$, $N = 44$, $p = .044$).

(3) Nineteen aviators out of 54 responses (12 pilots, 7 rear crewmen) felt that low G contributed to neck pain after flight without NVG. Results could not be predicted by crew position, anthropometric measures, or age.

(4) A higher proportion of pilots than rear crewmen considered low G with NVG to be a contributing factor in neck pain after flight with NVG, $\chi^2\,(2,54) = 6.148$, $p = .046$. Functional leg length approached significance with higher proportion of positive responses in the 1st and 4th quartiles, $\chi^2\,(6,54) = 12.369$, $p = .054$. A higher proportion of personnel in 2nd and 3rd quartiles for thigh clearance considered low G to be a factor in their neck pain, $\chi^2\,(6,54) = 14.640$, p=.023. The small number of aircrew with more than 3000 hours were more likely to consider low G with NVG a factor in neck pain after flight (G=0.325,N=53,p=0.018). Age was not significant.

(5) Eleven out of 49 aviators (6 pilots, 5 rear crewmen) responded that moderate G without NVG and 16 out of 49 aviators responded that moderate G with NVG contributed to neck pain after flying. Crew position, age, flying hours and anthropometric measures were not significant predictors of neck pain after moderate G flight.

(6) Posture was considered to be a factor after flight in 32 out of 56 aircrew without NVG (17 pilots, 15 rear crewmen), and 34 out of 55 aircrew with NVG. Crew position, age, flying hours and anthropometric measures were not predictive of post flight neck pain resulting from posture during flight.

(7) There were six responses relating to other factors contributing to neck pain after flight and those factors are listed in table 12 below.

Table 12.
Contribution of other factors to neck pain after flight.

Airframe	Contributing factor
TH-67 pilot	Clearing the aircraft following an injury
CH-47 crew chief	Heavy internal load operations/ body armor
OH-58 pilot	Posture-body armor
UH-60 pilot	Body armor
CH-47 pilot	CDU/ locking down at an angle
UH-60 pilot	Time flown

Neck pain severity

(1) Considering the worst episode of neck pain experienced, 53 aircrew responded, of these only one pilot reported incapacitating neck pain during flight but 6 pilots and 7 rear crewmen reported severe neck pain. There was no significant difference in severity between front and rear crewmen. There was no relationship between total number of hours flown with NVG and severity of worst neck pain.

(2) When considering the worst neck pain experienced after flight, 49 aircrew responded and of these two pilots and two rear crewmen reported incapacitating pain, compared with 9 pilots and 7 rear crewmen reporting severe pain. There was no significant difference between front and rear aircrew. Five out of 33 pilots and 2 out of 21 rear crewmen reported that their worst pain lasted more than 4 days after flight.

(3) The average severity of neck pain during flight was rated by 46 aviators. Of these two pilots and one rear crewmen rated their average neck pain during flight as severe. The aircrew with severe average neck pain were all in the first and second quartiles for functional leg length, $G = -0.456$, $N = 46$, $p = .029$. Only 30 reported their NVG counterbalance weight, and average neck pain during flight was reported as less severe in those with heavier NVG counterweight, $G = -0.533$, $N = 30$, $p = .015$). A higher proportion of individuals using lighter weight reported

their average neck pain as moderate and or those with heavier counterbalance weight reported mild average neck pain. There was no significant relationship between average severity and flying or NVG hours.

(4) Of 44 responses relating to average neck pain after flight, two pilots and two rear crewmen reported their average neck pain as severe with no significant difference between crew positions. Two out of 35 pilots reported that their average neck pain lasted for more than 4 days and 4 out of 21 rear crewmen thought that their average neck pain lasted 1-4 days after flight. A higher proportion of aviators in the 3rd and 4th quartiles for sitting height reported moderate to severe neck pain after flight compared with those with shorter sitting height, $G = 0.354$, $N = 44$, $p = .048$. Flying hours, NVG hours and NVG counterbalance weight were not good predictors of severity of neck pain after flying.

(5) Nine out of 51 aviators (4 pilots and 5 rear crewmen) felt that their neck pain affected their ability to perform mission-related tasks. The majority of aviators reporting an effect on mission-related tasks rated their worst episode of neck pain as severe during flight (G=0.536,N=53,p=0.013), worst neck pain after flight as severe, $G = 0.546$, $N = 49$, $p = .003$, average neck pain during flight as moderate to severe, $G = 0.721$, $N = 45$, $p = 0.004$, and average neck pain after flight as severe, $G = 0.660$, $N = 43$, $p = .017$. Worst neck pain lasting 1-4 days or more after flight, $G = 0.702$, $N = 55$, $p < .001$, and average neck pain lasting 12-24 hours, $G = 0.537$, $N = 57$, $p <.001$, were more likely to affect mission-related tasks. A few aviators clarified the effects on the mission and the details are listed in table 13.

Table 13.
Effect of neck pain on mission-related tasks.

Role	Effect of neck pain on mission-related tasks
Pilot	Sometimes mobility and reaction time
Pilot	On occasion it limits the range of motion
Pilot	Discomfort is distracting; hard to focus on tasks
Pilot	Avoid NVG flights
Crew chief	Airspace surveillance, pinnacle landings, external loads
Crew chief	Reduces scan rate, and ability to perform in-flight duties
Crew chief	Sling loads ops
Crew chief	Sometimes
Crew chief	Hinders concentration

Treatment for neck pain

(1) Twenty-three personnel sought treatment from a clinician. Of these personnel 16 attended a military doctor, 4 attended the chiropractor and 4 sought help elsewhere. Individuals who described their worst neck pain after flying as severe were more likely to attend the clinician, $G = 0.418$, $N = 48$, $p = 0.042$. Twenty aviators reported that they were given treatment for their neck pain and those personnel whose worst neck pain lasted longer than 1 day all received a therapeutic intervention, $G = 0.647$, $N = 54$, $p < .001$. Individuals who had a therapeutic intervention were more likely to have duration of average pain longer than 2-11 hours, $G = 0.623$, $N = 56$, $p < .001$.

(2) Five out of 22 aviators reported that they had been grounded due to neck pain. Two rear crewmen had been grounded for 2 weeks; two pilots and one rear crewman had been grounded for less than a week. All grounded aircrew reported worst neck pain lasting 12 hours or more after flight, $G = 0.661$, $N = 55$, $p = .021$, and average neck pain lasting more than 2 hours but less than 4 days after flight, $G = 0.709$, $N = 57$, $p = 0.021$.

Anthropometry and back pain

Back pain unrelated to flying

Back pain was more prevalent than neck pain. Forty-four out of 81 aviators complained of non flying-related back pain. There was no one factor that had any significance to non flying-related back pain. All respondents aged over 40 (12 individuals) complained of back pain unrelated to flying. Details of potential causative factors are listed in table 14.

Table 14.
Suggested causation of non flying-related back pain.

Suggested causation	Detailed description
Weight training and heavy lifting	Weight lifting- strained straight leg deadlift
	Lower back pain/ weight lifting related
	Lower back strain associated w/heavy lifting
	Weight lifting-- tightness, stiffness, pain
	Lower back pain from lifting weights
	Back lifted improperly, turned or twisted while working
	Heavy equipment lifting maintenance tools
	Carrying base drum in marching band
Sport and PT	Running or heavy lifting caused by lower back pain
	Injured my lower back during athletic activity
	Physical training
	Injury during pt
	Physical exercise
	Soreness from exercise
	Physical training related issues caused back and neck strain
	Waterskiing
	Back injury playing hockey
	Back pain from sports injury last month
	Lower back muscle pull from playing sports
	Injured back in high school football
	Physical exercise, soccer
	Bad posture, drafting, snowboarding, mountain biking, weight lifting, Football, being tackled, wrestling
	Back pain during decompression (hanging/stretching)
Accident	Post IED, muscle strain
	Fell off aft pylon of CH-47
	Motorcycle injuries
Military training/ overuse	Soreness due to overwork (road marching, dismounted, patrolling etc.)
	Lower back pain, over use/work
	10 years Infantry, Airborne, Air assault, M966 accidents
	Military vehicles as a passenger; NVG use since 1993
	Lower back pain after long flights
Posture	I'm a sloucher when sitting and bad sleeping habits; experience tightness and lack of mobility in full range motion.
Yard work	Stiff and back when working in the yard
Sleep	Just waking up in the morning (lower back pain)
	Sleeping wrong - stiff, Body armor - muscle fatigue – stiff
Unknown	Spontaneous onset, pain and spasm
	Discomfort neck back

Suggested causation	Detailed description
	Middle section stabbing pain
	Unknown/ maybe pulled muscle/ strain
	Pain along waist band area (lower back)
	Leg pain
	Have pulled muscles in back.

<u>Back pain related to flying</u>

(1) Back pain related to flying was reported in 66 out of 81 responses. Forty one out of 52 pilots and 24 out of 27 rear crewmen stated that they had flying-related back pain. The majority of rear crewmen with back pain were in 3rd and 4th quartiles for weight, $\chi^2(3,27) = 10.758$, $p = .013$, and 3rd and 4th quartiles for thigh clearance, $\chi^2(3,27) = 9.281$, $p = .026$. There was no significant correlation for back pain during flying and other anthropometric measures. Sixty one out of 69 respondents who provided total NVG hours complained of back pain and those who did not complain all had less than 1250 hours with NVG, $G = 0.571$, $N = 69$, $p = .045$. Details of reported in-flight contributors to back pain are listed in table 15.

<u>Table 15.</u>

Suggested contributors to back pain related to flying.

Suggested causation	Detailed description
	Compounds workout wear and tear
Posture	Posture related IOT see outside aircraft
	Sitting in cabin upright with no support
	Pain while just sitting during and after flight
	Lower back pain from lack of support
	Sitting upright, not able to rotate the seat back enough
	Inadequate lumbar support
	Back: Seat position so I added lumbar pillow to correct it.
	Seating position- lower back
Vibration	sitting position and vibration from flying if standing up
	Vibration
	Severe vibration
Body Armor/ ALSE gear	Lower back pain, 8 hr plus flights with ballistic plates
	Sore lower back after flying with body armor
	Body armor and ammo (M16/M4 ammo on ALSE vest) prolonged over 15 months
	Body armor causes back pain
	ALSE gear and seats
	Flights longer than 3 hours= back pain

Suggested causation	Detailed description
	After hours of flying
	Long flights sitting in chair
	Back pain during prolonged flight
	Lower back pain after long flights
	After long flights 3 hours or more
	Long hours (>6 hours) cause strain on neck and back
	8 hours in the cockpit
	Longevity of flight causes discomfort, demanding modes
	Long mission of 6 hours or greater while flying in Iraq with body armor
	Flying R-22 in small cockpit for prolonged periods; lower back soreness.
	Lower back was stiff after 6.0 hour flight(s)
	During long flights with both systems in combat
	Back: years of flying.
Night vision goggles/ long NVG flights	Wearing goggles
	Long NVG flights
	Long flights-- neck pain due to NVG and weight
	NVG/HUD use up to 6 hour flights
	Flying NVG and HUD several days in a row causes neck to hurt
	NVG flights
	Ongoing visits to chiropractor NVG wear, seating position in UH-60
	Long goggle flights/ L4/L5 fusion due to hard landing
	Long hours in poorly designed seats; helmet/ NVGs and hours of manipulating control display units in glass cockpits
	Repetitive use
Poor ramp seating	Sitting on ramp without any cushions during deployment
	Sitting on ramp and seat in cabin of CH-47
	Calling slingloads, riding ramp w/o seat, crew member seat
Loading cargo	Pushing cargo
	Loading/ unloading cargo
Unspecified	Back- injuries related to flying.
	Strain neck, pinch nerve lower back, strain and pull muscle lower Back
	Back spasms
	Lower back
	Both lower and upper back pain during 15 month deployment
	Numbness in hands and feet
	I assume it is from flying, my symptoms have been intermittent lower back pain. I have also had severe pain in my upper back extending from the spinal cord to my right elbow. This pain lasted 1 month and was 2 months prior to this survey.
	Minor lower back discomfort during cross country flights

Suggested causation	Detailed description
	Lower back tightness
	Middle back pain
	Lower back and neck
	Pain along waist band area (lower back)
	Lower and upper back/neck
	Lower back pain, HNP L5-S1; L4-L5 bulge

(2) Forty-one out of 53 pilots and 22 out of 26 rear crewmen had back pain during flying. Anthropometric measures, flying hours, NVG flight, crew position and age did not significantly affect the likelihood of back pain.

(3) Rear crewmen had more frequent episodes of back pain (though not quite significant) in individuals with head circumference in 3rd and 4th quartiles, $G = 0.515$, $N = 23$, $p = .051$. Other anthropometric measures, flying and NVG hours or age did not contribute significantly to reports of back pain during flying.

(4) Twenty-three out of 39 pilots and 16 out of 22 rear crewmen considered low G without NVG to be a contributory factor to their back pain during flying. A higher proportion of rear crewmen positive responses were in the 3rd quartile for thigh clearance (8 out of 16 positive responses), $\chi^2(6,22) = 12.696$, $p = .048$. No other anthropometric measure, age or flying hours reached significance.

(5) Twenty-one out of 38 pilots and 17 out of 21 rear crewmen responding considered low G with NVG a contributory factor to low back pain. The majority of aviators considering low G with NVG a factor in back pain during flight had flying hours ranging from 1000 - 2000 hours, $G = 0.367$, $N = 58$, $p = .030$, and those with more than 1500 hours had higher proportion of positive responses. Those aviators with 41 or more flying hours in the preceding 28 days all considered low G with NVG a contributing factor to back pain during flight, $G = 0.390$, $N = 59$, $p = .013$.

(6) Fourteen out of 31 pilots and fourteen out of 20 rear crewmen considered moderate G without NVG to be a contributing factor to back pain during flight. Thirteen out of 31 pilots and 15 out of 21 rear crewmen considered moderate G with NVG to be a contributing factor. Anthropometric measures, crew position, flying hours and age were not significant in personnel with positive responses.

(7) The majority of respondents, 33 out of 39 pilots, and 23 out of 24 rear crewmen, considered posture without NVG to be a factor in back pain during flight. Positive responses were spread over all age groups but only three individuals in the 35 to 39 age group and one in the 45 to 49 age group reported that posture was not an issue, $\chi^2(5,61) = 11.223$, $p = .047$. There was no significant difference within the anthropometric measurements.

(8) When considering the influence of posture with NVG on back pain during flight 29 out of 37 pilots and 22 out of 24 rear crewmen reported that this was a factor. Two negative responses when related to age group were in 19 to 24 and 35 to 39 age group, χ^2 (5,54) = 27.437, *p* < .001, the remainder reported not applicable. The majority of personnel were in the 3rd and 4th quartile for neck circumference, χ^2 (4,61) = 11.443, *p* = .022. Most pilots were in the 4th quartile for neck circumference, χ^2 (4,37) = 13.313, *p* = .010. No other anthropometric measure was significant. Of the nine people who responded not applicable or that posture was not a contributing factor, all had less than 2000 total flying hours, *G* = 0.741, *N* = 60, *p* = .003, and less than 20 hours flying in the last 28 days, *G* = 0.604, *N* = 61, *p* = .002.

(9) Six pilots considered other factors to be influential in causation of back pain during flight. These are listed in table 16 below.

<u>Table 16.</u>

Contribution of other factors to back pain during flight.

Airframe	
CH-47 pilot	Additional worn equipment
UH-60 pilot	Time >3 hours
OH-58 pilot	Body armor
UH-60 pilot	Body armor
CH-47 pilot	Heavy ALSE vest and plates
TH-67 pilot	Any flight greater than 1 hr-15

(10) The majority of aviators that quantified duration of back pain when flying without NVG (66 responses) were in the top quartile for weight. Eighty percent of those in the 1st quartile for weight had in-flight back pain lasting more than 90 minutes and the highest proportion of personnel with pain lasting more than 90 minutes were in the 4th quartile for weight, *G* =- 0.397, *N* = 66, *p* = .007. A higher proportion of individuals with larger thigh clearance had shorter duration of in-flight back pain, *G* = -0.314, *N* = 66, *p* = .012. Individuals with 3000 or more flying hours all reported back pain lasting 75 minutes or more during flight, *G* = 0.282, *N* = 65, *p* = .023). No other factors including age or crew position were significant.

(11) Aviators in the 1st quartile for weight were more likely to have back pain lasting more than 90 minutes when flying with NVG, *G* = -0.518, *N* = 60, *p* < .001. A higher proportion of personnel with thigh clearance in the 3rd and 4th quartiles had shorter duration back pain, *G* = -0.247, *N* = 60, *p* = .047, and those with smaller head circumference had longer average duration back pain than those with larger head circumference, *G* = -0.253, *N* = 60, *p* = .043. No other anthropometric measures, age or crew position reached significance. The proportion of aviators reporting long duration of in-flight back pain when using NVG was higher in those with 3000 or more flying hours, *G* = 0.355, *N* = 59, *p* = .005.

Back pain after flying

(1) Sixty-four out of 80 respondents experience back pain after flight. The majority of these personnel were in the 25 to 39 age group, $\chi 2$ (8,81) = 19.702, $p = .012$. Anthropometric measures or crew position was not significant predictors of post flight back pain. The largest number of respondents were in the 25 to 39 age group but the small number of respondents in 45 to 59 age group had an increased proportion of the group reporting back pain, $\chi 2$ (8,81) = 19.702, $p = .012$. The majority of personnel with pain after flying had more than 1000 flying hours, $G = 0.527$, $N = 77$, $p = .014$), and more than 11 flying hours in the last 28 days, $G = 0.390$, $N = 78$, $p = .034$, with the largest number having 1000 to 2300 total flying hours and 11 to 30 flying hours in the last 28 days.

(2) The number of episodes of back pain, reported by the 65 aviators responding, was not related to crew position or anthropometric measures however, age approached significance with the aircrew between ages 30 to 39 having the highest number of episodes but also being the largest population, $G = 0.348$, $N = 65$, $p = .054$.

(3) Thirty out of 56 respondents (18 pilots, 12 rear crewmen) felt that low G contributed to their low back pain after flight without NVG. A higher proportion of positive responses were in the fourth quartile for leg length, $\chi 2$ (6,56) = 15.306, $p = .018$. Crew position, age and other anthropometric measures were not significant. Aviators with 41 or more hours in the last 28 days were more likely to consider low G without NVG a contributing factor to their back pain after flight, $G = 0.348$, $N = 56$, $p = .013$.

(4) Thirty-three out of 57 aviators (21 pilots, 12 rear crewmen) felt that low G contributed to their back pain after flight with NVG. Positive responses for low G were spread over all quartiles but the highest proportion (15 out of 18 respondents) was in the 4th quartile for functional leg length, $\chi 2$ (6,57) = 15.746, $p = .015$. Age, crew position and all other anthropometric measures were not significant. Those least likely to consider low G with NVG a factor had less than 1500 total flying hours, $G = 0.344$, $N = 56$, $p = .043$ and less than 20 hours in the last 28 days, $G = 0.552$, $N = 57$, $p = <.001$.

(5) Seventeen out of 51 aircrew (8 pilots, 9 rear crewmen) felt that moderate G was a contributory factor to their back pain after flight without NVG. No specific measure, age or crew position was more at risk.

(6) Nineteen out of 51 (9 pilots, 10 rear crewmen) felt that moderate G was a factor in their back pain after flight with NVG. No specific anthropometric measure, crew position or age was a predictor of effect of moderate G. Aircrew with 41 hours or more in the last 28 days were more likely to consider moderate G with NVG a contributing factor to their back pain after flying, $G = 0.331$, $N = 51$, $p = .031$).

(7) Fifty-four out of 62 (32 pilots, 22 rear crewmen) respondents felt that posture contributed to their back pain after flight without NVG. There was no significant difference between different anthropometric measures, age or flying hours.

(8) Fifty out of 60 aviators (30 pilots, 20 rear crewmen) felt that posture contributed to back pain after flight with NVG. The highest number of personnel reporting posture with NVG contributing to back pain after flight had flown between 11 and 30 hours in the last 28 days, G = 0.499, N = 60, p = .011 and had 250-500 total NVG hours, G = 0.889, N = 54, p = .033. No other anthropometric factor or age was significant.

(9) Six aviators commented on other factors that affected their back pain after flight. These are listed in table 17.

Table 17.
Contribution of additional factors to back pain after flight.

Airframe	Contributing factor
CH-47 pilot	Additional worn equipment
OH-58 pilot	Body armor
UH-60 pilot	Body armor
CH-47 pilot	Hours of flying with heavy vest and poor posture
UH-60 pilot	Time flown more than 3 hours
CH-47 crew chief	Vibration

Back pain severity

(1) Of 71 responses regarding severity of back pain during flight, 15 out of 45 pilots and 8 out of 25 rear crewmen reported their worst back pain as severe during flight.

(2) Of the 72 aircrew who rated the worst back pain that they had after flight, 4 out of 45 pilots and 7 out of 26 rear crewmen complained of incapacitating pain; 12 pilots and 8 rear crewmen complained of severe pain. The duration of worst back pain was more than 4 days after flight for 4 out of 36 pilots and 8 out of 26 rear crewmen.

(3) Sixty-nine aircrew rated average back pain during flight. The majority complained of mild to moderate average pain. Only one out of 24 rear crewmen complained of incapacitating pain; 5 out of 44 pilots and 3 out of 24 rear crewmen complained of severe pain. The majority of respondents reported back pain as mild to moderate during flight but those with flying hours of 3000 hours or more, though fewer in number, were more likely to report severe to incapacitating pain, G = 0.383, N= 67, p = .009. Those with severe or incapacitating pain reported flying hours in the range of 11 to 50 hours in the last 28 days, G = 0.268, N = 68, p = .052.

(4) 71 aviators rated their average severity after flight. Unsurprisingly, aviators with lower total flying hours reported less severe pain with the majority of those with less than 500 hours reporting average back pain after flying as mild, G = 0.374, N = 69, p = .004.

(5) The number of back pain episodes after flying was not significantly different between front and rear crewmen and the majority of positive responses reported more than 10 episodes.

(6) Duration of average back pain after flying was more than four days for four out of 46 pilots and three out of 26 rear crewmen. There was no significant difference between pilots and rear crewmen. As flying hours increased the proportion of respondents with prolonged back pain increased, $G = 0.449$, $N = 71$, $p < .001$, particularly among those with more than 3000 total flying hours. Those with flying hours in the last 28 days of less than 10 hours had shorter duration back pain after flight, $G = 0.216$, $N = 72$, $p = .049$.

(7) Twenty-eight personnel had been grounded for flight-related back pain and of these the maximum period of grounding for pilots was three to four weeks and for rear crewmen was greater than a month. Duration of grounding increased as the quartile for thigh clearance increased, though numbers in each group were small, $G = 0.519$, $N = 28$, $p = .014$.

(8) Sixteen aircrew, 4 pilots and 12 rear crewmen felt that their back pain was severe enough to affect their ability to carry out mission-related tasks with increased likelihood among rear crewmen, $\chi^2 (4,83) = 15.704$, $p = .003$. Individuals reporting worst back pain during flight as severe or incapacitating, $G = 0.570$, $N = 70$, $p = .001$, worst back pain after flight of increasing severity above mild, $G = 0.612$, $N = 71$, $p < .001$, average back pain during flight of moderate to severe $G = 0.684$, $N = 69$, $p < .001$, increasing severity of average back pain after flight above mild, $G = 0.531$, $N = 70$, $p = .003$, duration of worst back pain of longer than 1 day, $G = 0.632$, $N = 72$, $p < 0.001$, and increasing duration of average pain, $G = 0.362$, $N = 72$, $p = .015$, were more likely to consider that their pain affected their ability to perform mission-related tasks. Rear crewmen had a higher proportion of reports of back pain affecting mission-related tasks (12 out of 28) compared with pilots (4 out of 53), $\chi 2$ (4,83) = 15.704, $p = .003$. Aircrew with total flying hours greater than 3500 did not report effects of back pain on mission-related tasks, $G = 0.349$, $N = 80$, $p = .003$ however those with total NVG hours of 750 or more were more likely to report back pain affecting the mission, $G = 0.529$, $N = 70$, $p < .001$). Details of reported effects of back pain on mission-related tasks are listed in table 18.

Table 18.
Reported effect of back pain on ability to perform mission-related tasks.

Role	Effect of back pain on mission-related tasks
Pilot	Mobility and reaction time
Pilot	Discomfort is distracting
Pilot	Yes, if focused on pain- less concentration on reconnaissance. It acted as a severe annoyance, would shorten total mission duration
Pilot	Discomfort is distracting; hard to focus on tasks
Pilot	Any movement
Crew Chief	Bending, twisting, lifting, sitting, standing, moving
Crew Chief	Bending down, sitting, standing
Crew Chief	Every task
Crew Chief	Loading cargo, and external load operations.
Crew Chief	Hard to do sling loads
Crew Chief	At times makes it tough to work
Crew Chief	Sling load task and long flights
Crew Chief	Hinders concentration
Crew Chief	Lifting heavy equipment
Crew Chief	Slows down the ability to get in and out of aircraft.
Flight Medic	General crew duties

(9) Only individuals with less than 500 flying hours reported worst back pain lasting during flight only. The three aviators with 4500 or more flying hours all reported duration of worst back pain of more than 4 days, $G = 0.481$, $N = 71$, $p < .001$, however a duration of more than 4 days was also reported in all flying hour groups except those with less than 500 hours. Duration of the worst episode of back pain was longer in a higher proportion of individuals with total NVG hours exceeding 750 hours, $G = 0.395$, $N = 66$, $p < .001$. The duration of average back pain was shortest in individuals with total NVG hours less than 750, $G = 0.277$, N = 66, $p = .010$. NVG hours in last 28 days was not a significant factor in severity or duration of back pain.

(10) Aircrew who were grounded for longer than 3 weeks all had more than 1250 total NVG hours, $G = 0.556$, $N = 28$, $p < .001$. NVG counterbalance weight was not a determining factor for severity, duration or length of grounding for back pain.

Treatment for back pain

(1) Forty-one aviators sought treatment for back pain. Of those 27 attended a military doctor, 1 attended a civilian doctor, 3 attended the chiropractor and 9 sought help elsewhere. Aircrew were more likely to attend a clinician if the worst episode of back pain was rated above moderate pain both during, $G = 0.658$, $N = 71$, $p < .001$ and after flight $G = 0.720$, $N = 82$, $p < .001$. Severity of average back pain during flight, $G = 0.402$, $N = 69$, $p = .041$, and average back pain after flight, $G = 0.525$, $N = 71$, $p = .004$, above moderate severity also increased likelihood of seeking treatment. Duration exceeding 1 day for worst pain, G=0.738, $N = 73$, $p < .001$, and beyond 12 hours for average pain, $G = 0.543$, $N = 73$, $p < .001$ were also factors in seeking help for back pain.

(2) Thirty-three out of 45 respondents required a therapeutic intervention for their back pain. Likelihood of intervention increased as severity of worst back pain increased above mild, both during flight $G = 0.544$, $N = 44$, $p = .023$, and after flight, $G = 0.932$, $N = 45$, $p = .012$. Duration of back pain and average back pain were not reliable predictors of treatment.

(3) Eighteen aviators had been grounded for back pain (7 pilots and 11 rear crewmen). The relative proportion of rear crewmen grounded was higher than for pilots, $\chi 2$ (2,83) = 8.745, $p = .013$. Increasing severity of worst episode of back pain during flight beyond moderate, $G = 0.587$, $N = 70$, $p = .005$, increasing severity after flight, $G = 0.809$, $N = 71$, $p < .001$, with 10 out of 18 grounded rating their back pain as incapacitating, increasing severity of average back pain during flight, $G = 0.515$, $N = 68$, $p = .028$, and after flight, $G = 0.515$, $N = 70$, $p = 0.001$, increasing duration of worst back pain, $G = 0.795$, $N = 72$, $p < .001$, with 11 out of 18 grounded reporting pain that lasted longer than 4 days, and increasing duration of average pain, $G = 0.534$, $N = 72$, $p = .002$, were all significant factors in aviators grounded due to back pain.

(4) For those grounded due to back pain, one out of 28 rear crewmen was currently grounded, 1 rear crewmen had been grounded for more than a month; one out of 15 pilots and two rear crewmen were grounded for three to four weeks. Those individuals with a thigh clearance in the 4th quartile were more likely to be grounded for back pain, $G = 0.519$, N =28, $p = .014$.

Additional sources of treatment for neck and back pain

Individuals were asked to comment on additional sources of treatment. There were 41 responses and many had sought more than one form of treatment. The most common source of treatment was chiropractic manipulation with 26 individuals having attended the chiropractor at some time. Twenty-one individuals had attended physical therapy, eight of which had physical therapy alone and the remainder had more than one source of therapy. One individual had had surgical treatment and one was on the waiting list for a surgical procedure. Two individuals had pain severe enough to require epidural, two required opiates, four required muscle relaxants, ten used non-steroidal anti inflammatory drugs (NSAIDs) and six did not specify their medication type. Ten had attended a military doctor, eight a civilian doctor and five a physician’s assistant. Other treatments described included traction (3 responses), massage (4 responses), acupuncture (1 response) and bed rest (1 response).

Prevention of neck and back pain

(1) Thirty-one out of 75 aviators responded that they had taken action to minimize flight related neck pain. Individuals with a worst episode of neck pain lasting longer than 12 hours after flight were more likely to take action to minimize flight related neck pain, $G = 0.722$, $N = 52$, $p < .001$. All those with average neck pain lasting longer than 24 hours took action to minimize neck pain, $G = 0.586$, $N = 54$, $p < .001$.

(2) Fifty-two out of 70 aviators had taken some form of action to minimize or prevent back pain. The majority of aircrew seeking treatment reported worst back pain during flight as moderate to severe, $G = 0.509$, $N = 70$, $p = .006$. Aircrew were more likely to take action with increasing severity of worst back pain after flight, $G = 0.430$, N=71, $p = .013$, and all aircrew reporting incapacitating pain after flight had taken some action to minimize pain. Those who rated average back pain during flight as moderate were most likely to have taken some action, $G = 0.584$, $N = 69$, $p = .003$, and proportion reporting taking action increased as duration of worst back pain, $G = 0.569$, $N = 72$, $p < .001$, and average back pain increased, $G = 0.552$, $N = 72$, $p < .001$. Examples of some actions taken by aviators are listed in table 19 below.

Table 19

Action taken by aviators to minimize neck and back pain.

Back or neck	Action taken	Effectiveness of action
	CUSHIONS	
Back	Bought aftermarket ortho seat cushion	
Back	Purchased after market seat cushions	
Back	Purchased Oregon Aero seat and lumbar cushion	Yes 100 percent effective
Back	By purchasing an Oregon Aero seat cushion	
Back	Use an extra back seat cushion as support	
Back	Extra seat cushion and placement of back pad.	
Back	Extra seat cushions Stretching	
Neck and back	Cushion Change my posture in aircraft	
Neck and back	Use of inflatable seat cushion Leg stretching/flexibility exercises	Helped lower back Help
Neck and back	Re-arrange ALSE gear Use various cushions	
	LUMBAR SUPPORT	
Back	Lumbar support	
Back	Lumbar support	
Back	Lumbar support; Gel seat cushion	Somewhat effective

Back or neck	Action taken	Effectiveness of action
Neck and back	Back- lumbar pillow Neck- Physical Therapy traction	
Neck and back	Lumbar support Physical therapy Chiropractor Mobic meds	Effective Inconclusive Effective Effective
Neck and back Neck and back	Remove headrest Lumbar support Posture Exercise	
STRETCHING		
Back	Stretching prior to each flight	Effective
Neck and back	Change seated position in A/C Stretching in-flight --not effective	Not effective Not effective
Neck and back	Stretching Seat cushions Change seat position Exercise	
Neck and back	Stretching Changing seat position in flight	
Neck and back	Stretching	
Neck and back	Stretching before and after flights	
Neck and back	Standing up during flight Lying down	
Neck and back	Stretch before/after flight Adjust seat in UH-60M	
Neck and back	Practice standing during flight	
EXERCISE		
Back	Exercise Dead lifts, squats	
Neck and back	Exercise, stretching, support pillows	
Neck and back	Exercise and stretching	somewhat effective
Neck and back	Exercise and stretching Heat therapy and soaking in epsom salt	
Neck and back	Neck exercises, yes effective	effective
Neck and back	Neck and back exercises Don't do sling loads all the time	
Neck and back	More frequent exercises	
Back	Stay fit (working out in the gym)	
Neck and back	Motrin Exercise	
Neck and back	Push less pallets	

Back or neck	Action taken	Effectiveness of action
	Do less sling loads Change crew position	
	POSTURE	
Back	Slouch over to reduce the upper body Weights and resting elbows on knees.	
Neck and back Neck and Back	Proper posture Counter balance weights	
	PT AND CHIROPRACTOR	
Back	Brace Meds Physical therapy	
Back	Chiropractor appointments	Very effective
Back	Surgery PT Chiropractor	Getting better Not really effective Somewhat effective
Back	I've had a massage while on mid-tour leave.	It was effective combined with time out of the cockpit.
Neck and back	Physical therapy	
Neck and back	Saw a chiropractor	Very effective
Neck and back	Motrin Icy hot	
	OTHER	
Back	Shortening length of flights	Yes effective
Back	Swap position in aircraft	
Neck and back	Stopped flying	
Neck and back	Counter weights Alternate seating	
Neck and back	Seek medical attention- spend thousands of dollars to rectify problem	
Neck and back	Sought medical advice	

Effect of back and neck pain on leisure activities

(1) Twenty-five of the 75 aviators responding (15 pilots, 9 rear crewmen, 1 not specified) felt that their neck pain was severe enough to affect their leisure activities and likelihood increased with increasing severity of worst neck pain during flight, $G = 0.628$, $N = 48$, $p = .001$, increased severity of worst neck pain after flight, up to a rating of severe, $G = 0.602$, $N = 45$, $p = .001$, increased average severity of neck pain after flight, $G = 0.500$, $N = 41$, $p = .051$, increasing duration of worst neck pain beyond 12 hours, $G = 0.710$, $N = 51$, $p < .001$, and average neck pain beyond 12 hours, $G = 0.666$, $N = 53$, $p < .001$.

(2) Fifty aviators (28 pilots and 22 rear crewmen), reported that their back pain affected their leisure activities. Rear crewmen were more likely to complain, $\chi2\ (2,80) = 7.479$, $p = .024$. Severity of worst back pain during and after flight rated moderate or higher was more likely to affect leisure activity, $G = 0.866$, N = 68, $p < .001$, and $G = 0.895$, $N = 69$, $p = .001$ respectively, as was average back pain during flight, $G = 0.728$, $N = 66$, $p = .001$, and after flight, $G = 0.495$, $N = 68$, $p = .016$, with all respondents who reported average pain as severe after flight considering the pain to have an effect on leisure activity. Duration of worst pain exceeding two hours after flight, $G = 0.613$, $N = 70$, p < .001, and average pain greater than two hours after flight, $G = 0.580$, $N = 70$, $p < .001$, were more likely to affect leisure activity. The most commonly affected activity was sleep, followed closely by physical activities. The details of affected activities are listed in table 20.

Table 20.

Effect of neck and back pain on leisure activities.

Neck or back	Effect on leisure activity
SLEEP	
Neck	Have to sleep with towel rolled up in pillow to reduce neck stiffness
Neck	Sleeping
Back	Sleep, unable to sleep on back. PT, unable to jog.
Back	Sleeping is restless maybe 1-2 nights out of week; sometimes wake up feeling un-rested as a result
Back	Sleeping
Back	Sleep
Back	Sleep sometimes, standing
Back	Sleeping is restless maybe 1-2 nights out of week; sometimes wake up feeling un-rested as a result
Back	Sleeping
Back	Hard to sleep with lower back pain.
Back	Sleep
Back	Sleep is uncomfortable
Back	Sleep driving running
Back	Sleep and exercise (running hanging during pull ups)
Back	Sleep, driving, sports
Back	Driving, sleeping, hunting, watching TV, sitting, walking ect. Ect. Ect.

Neck or back	Effect on leisure activity
Back	Walking, running, sleeping, sports
Neck and Back	Sleep, unable to get position of comfort, sports, unable to workout weights or running
Neck and Back	Sleep, normal movement
Neck and Back	Sleeping, driving
Neck and Back	Sleep, drive, run, and workouts at gym.
Neck and Back	Reduces ability to do certain activities/ need extra neck support for sleep
Neck and Back	Neck pain affects sleep and back pain affects driving long distance
Neck and Back	Hunting, driving, sleeping, walking, putting uniform on.
Neck and Back	Sleep; physical activities to a minor degree.
Neck and Back	5 to 6 hours of sleep due to neck and back pain. Limited pt- no running, sit ups. Playing ball with my children is out of the question.
PHYSICAL ACTIVITY/SPORT/HUNTING	
Back	My ability to exercise has diminished
Back	Exercising, riding my motorcycle
Back	Hunting, sports
Back	Sports, motorcycle riding.
Neck and Back	Any physical activities, lifting, running etc., sitting and laying down.
Neck and Back	Running is difficult at times and I have to watch what I do so I don't cause further injury when it's tender.
Neck and Back	Limits sports or other activities
Neck and Back	Can’t do sit-ups anymore
Neck and Back	Yard work is limited so that back isn’t strained.
Neck and Back	Driving, sports or other physical activities
DRIVING	
Neck	Only twice. Nerve pinched so it was difficult to turn head to view blind spots, shifting difficult due to shoulder motion on shifter.
Back	Driving or sitting for long periods
Back	Driving, sitting for long period of time
Back	Driving- I try not to drive more than 3 hours straight. Skydiving- I pack <u>very</u> carefully to avoid hard openings.
Neck and Back	Limited back and neck mobility impairs driving, riding motorcycle
Neck and Back	Driving, motorcycling, sports.
OTHER	
Back	Occasional back pain limits mobility. Recovery usually occurs within 24-48 hours
Back	Any sitting for ext period of time- uncomfortable. Lifting- difficult.
Back	Try not to do things that aggravate it.
Back	All, pain always present
Neck and Back	Normal living- sometimes I have to limit my normal movements until nerves

Neck or back	Effect on leisure activity
	are relaxed by medication (motrin mostly) or chiropractic.
Neck and Back	Almost impossible to sit still; constantly stretching neck/back and "cracking" my neck.
Neck and Back	Randomly everything

Summary of results and discussion

Examination of the nine anthropometric measures used in the study found a significant relationship between weight, neck circumference, and thigh clearance. This relationship did not always carry across into statistical significance when examining neck and back pain reports in aviators. Unsurprisingly, age also correlated with flying hours, particularly in those older than 45 years who had more than 2500 total flying hours. Age was therefore a significant confounder when considering the effect of flying hours on neck and back pain. The limited number of volunteers prevented analysis of percentiles which would be more likely to identify cut offs in anthropometric parameters in certain situations.

Consideration of anthropometric measures is essential when considering ergonomic design of cockpit and cabin spaces. Most cockpit spaces are designed to accommodate individuals between the 5^{th} and 95^{th} percentile. For this reason quartiles are relatively insensitive in detection of ergonomic difficulties. Despite this, when both pilots and rear crewmen were considered together, and rear crewmen were considered alone, aviators with longer buttock knee length reported the need to slouch both with and without NVG. Increasing weight, with the corresponding increase in neck circumference, was a factor in pilots both in overall comfort and in achieving collective reach. It is suspected that this effect on collective movement may have resulted from restricted movement of larger aviators in an already cramped cockpit area.

A large proportion of pilots (59 percent) complained that their back was not fully supported in the flying position. A study among professional bus drivers found a relationship between back symptoms and drivers complaining mover frequently of uncomfortable seats or uncomfortable back supports (Alperpvitch-Najenson et al. 2010). Comfort is often not a strong enough justification for changing seat design or seat cushions, however it may be indicative of long term postural changes that could cause longer term back complaints. Lumbar supports were commonly used by pilots and seat pan cushions by rear crewmen to improve comfort but, specific cushions were rarely described.

Neck pain

Extremes of functional leg length appeared to be a risk factor for neck pain with those in the 4^{th} quartile being more likely to report neck pain related to flying. Aircrew rating their average neck pain as severe, were all in the first and second quartiles for functional leg length but this relationship was not present when considering overall stature. Individuals in the 1^{st} and 2^{nd}

quartiles were more likely to consider low G with NVG as a contributory factor to their neck pain during flight and in the 1st and 4th quartiles for low G with NVG after flight.

The highest reported number of episodes of neck pain during flight, were in the 2nd quartile for buttock knee length.

Individuals who had the shortest sitting height were least likely to report neck pain during flight. More neck pain was reported during flight among individuals in the 2nd quartile for sitting height. More severe neck pain was reported in the 3rd and 4th quartiles for sitting height which would logically correspond with individuals more likely to stoop in the aircraft though the relationship between stooping and neck pain was not assessed. A study examining neck pain in children found an inverse relationship between body height and neck pain history (Poussa et al., 2005a). Though overall stature did not show any significant effects in this study, sitting height influenced neck pain during flight and this relationship of smaller stature and neck pain may merit further investigation. None of the individuals in the 4th quartile for sitting height considered moderate G without NVG to be a factor in their neck pain and the highest proportion who considered moderate G with NVG to be a factor were in the 3rd quartile for sitting height. Smaller sitting height may thus be a protective factor in some individuals, though this protective effect was not statistically evaluated.

Weight was another measure that was associated with increased reports of neck pain related to flying, particularly among rear crewmen in the 4th quartile. These rear crewmen were also more likely to consider posture with NVG as a contributing factor to their neck pain during flying. This likely reflects the population skew to the 3rd and 4th quartiles as discussed earlier.

Individuals with neck pain were more likely to have higher number of flying hours suggesting that there is a cumulative effect of flying hours and pain. Respondents with less than 1000 total flying hours were less likely to report neck pain after flying. Those with more than 3000 hours all considered low G with NVG (normal NVG flight) and posture with NVG to be a contributory factor to their neck pain during flight and low G with NVG was a factor after flight. All aviators who responded that posture was not contributory during flight with NVG had less than 2500 total flying hours and less than 750 NVG hours.

Age was expected to correlate with flying hours in significance but this relationship was not evident in the statistical analysis. The majority of responses were in the 30 to 39 age group and thus this age group was more likely to report symptoms. Aviators less than 24 years of age did not report flying-related neck pain and these individuals all had less than 500 flying hours. The small number of respondents age 55 or older all reported neck pain during flying.

NVG counterweight was a potential factor in neck pain, but the data were limited to only 30 responses. Of these 30, neck pain was less severe in those with heavier NVG counterweights. A recent study demonstrated the benefit of improving helmet fit in Dutch aircrew, purpose of reducing helmet gliding, neck load and hotspots but also with a resultant reduction in neck pain (Van den Oord et al., 2012). The combination of improved helmet fit and optimal counterbalance weight will likely improve neck pain in several aviators and more work in this area would be beneficial.

The effect on mission-related tasks was most closely related to reported severity of both average and worst neck pain and thus it is essential not only that we work to prevent neck pain, but also, to minimize the severity of neck pain through early intervention, when it occurs.

Back pain

Back pain had a high prevalence with 54 percent of aircrew reporting back pain not related to flying and 82 percent of aircrew reporting flying-related back pain. The presence of non-flying related back pain was a major confounding factor when assessing the influence of flying on individual symptoms.

There was no correlation between back pain prevalence and stature and this finding was similar to findings in Brazilian truck drivers (Andrusaitis, Oliveira, and Filho 2006). The effect of the skewed weight data was more obvious in back pain where back pain on the whole was more prevalent within the study population. The majority of rear crewmen who complained of flying-related back pain were in the 3rd and 4th quartiles for weight, as well as the 3rd and 4th quartiles for thigh clearance. The highest proportions of aviators complaining of back pain lasting more than 90 minutes during flight were in the 4th quartile for weight. Interestingly when flying with NVG, those in the 1st quartile for weight were more likely to complain of back pain lasting more than 90 minutes.

Functional leg length could alter the posture of an individual with long legs requiring either the legs to be more flexed or the individual to push back into the seat. Short legs can result in an individual sliding down the seat to reach the pedals, though this was not reported in the survey. It was anticipated that leg length would contribute to back pain. Individuals in the 4th quartile for leg length were more likely to consider low G with or without NVG to be a factor in their back pain. Leg length was not significant in any other measures.

The remainder of significant findings for back pain all relate to flying hours and age. Aviators with more than 3000 flying hours all reported back pain lasting more than 75 minutes during flight. They were also more likely to report their worst pain as severe to incapacitating. The majority of individuals who reported back pain after flying had more than 1000 total flying hours. Those aviators least likely to consider low G with NVG as a factor all had less than 1500 total flying hours. Surprisingly, aircrew with more than 3500 hours did not report an effect of back pain on mission-related tasks. It is likely that there is some contribution of the healthy worker effect with individuals moving to non-flying-related tasks or retiring as a result of health issues if pain affected mission-related tasks. Accounting for symptoms among medically retired personnel or veterans would give a more realistic indication of the effect of age and flying hours on back pain but this was beyond the scope of this study. A study found that individuals in the highest quartile for height with low back pain were at higher risk of progressing to surgery (Coeuret-Pellicer et al., 2010). Detail of surgical intervention was not obtained in this study but this is another potential reason for individuals to discontinue flying.

The effect of back pain on mission-related tasks was related to severity of worst and average pain as well as duration of symptoms.

Conclusions

In summary, weight and neck circumference distribution was not representative of 1988 percentiles and increases in these values were associated with neck pain in rear crewmen during flight and also in complaints of back pain. Back pain was more prevalent than neck pain among aviators. The most common complaint among aviators was lack of back support and contribution of posture to back pain, particularly among the rear crewmen. Individuals with smaller sitting height, fewer flying hours, and heavier NVG counterbalance weights reported less neck pain and there is scope for more detailed examination of the influence of sitting height and NVG counterbalance on neck pain.

Quartiles of anthropometric measures are not sensitive enough to be used in evaluation of anthropometric data as risk factors in development of pain. Age and flying hours were the best predictors of pain severity and pain severity was the best predictor of effect on mission-related tasks.

Many aviators were using additional cushions and there is scope to examine different styles of lumbar cushions to see if this improves reports of discomfort, back pain, and the effect on mission-related tasks.

There is scope to repeat the study with a larger subject population to enable more detailed analysis of percentiles, particularly related to sitting height, functional leg length, and weight.

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Appendix A.

Questionnaire.

Aircrew Neck and Back Pain Survey

SECTION 1: Personal Details

Please fill in the blanks or check the boxes as appropriate.

Q1. i. Age: 19-24 [ ] 25-29 [ ] 30-34 [ ] 35-39 [ ] 40-44 [ ] 45-49 [ ]

ii. Gender: Male [ ] Female [ ]

iii. Please fill in the following table to indicate, on average, how often you have exercised over the last year, and what form of exercise you have undertaken.

Frequency	Aerobic exercise (e.g., running, cycling)	Weight lifting	Specific neck exercises	Specific back exercises	Other (please specify)
Everyday	[ ]	[ ]	[ ]	[ ]	[ ]
2-5 times per week	[ ]	[ ]	[ ]	[ ]	[ ]
Once per week	[ ]	[ ]	[ ]	[ ]	[ ]
1-3 times per month	[ ]	[ ]	[ ]	[ ]	[ ]
Less than once per month	[ ]	[ ]	[ ]	[ ]	[ ]
Never	[ ]	[ ]	[ ]	[ ]	[ ]

Q2. i. In which year did you begin your military flying career?
Year: __________

ii. What is your current aircrew position?

Aviator [ ]

Crew Chief [ ]

Other (please specify) _______________

iii. From your flying log book, what is your total number of flying hours to date?

Total flying hours __________

Flying hours in last 28 days __________

v. Please specify the types of aircraft you have flown or crewed within the last ten years, starting with the most recent. Include the total number of years and the approximate number of hours logged in each (e.g., UH-60, 2 years, 300 hours):

Aircraft Type	Total Years in Aircraft	Total Hours in Aircraft
__________	__________	__________

SECTION 2: Current aircraft details

The following questions should be answered with regard to your experiences in your current aircraft type wearing ALSE gear.

Q3. i. Can you comfortably sit fully upright in the cockpit wearing your personal ALSE?

Yes	No
[ ]	[ ]

ii. Rate your comfort while in the aircraft on the scale below

No discomfort ... unbearable discomfort

0	1	2	3	4	5	6	7	8	9	10

iii. When sitting fully upright with the harness locked, do you experience any difficulties reaching the flying controls?

	No difficulty	Mild difficulty	Moderate difficulty	Severe difficulty
Cyclic	[ ]	[ ]	[ ]	[ ]
Collective	[ ]	[ ]	[ ]	[ ]
Pedals	[ ]	[ ]	[ ]	[ ]

iv. Do you have to slide down in your seat (slouch) or bend your neck or back to fit in the cockpit/ cabin?

Yes	No
[ ]	[ ]

v. When wearing night vision goggles (NVG) or helmet mounted displays (HMD), do you have to slouch or bend your neck or back to fit in the cockpit/cabin?

Yes	No
[ ]	[ ]

vi. Does your head strike any of the cockpit or cabin components (e.g. roof, overhead panels, overhead lights, levers, etc.)?

	Yes	No	Not Applicable
When sitting upright without NVG/HMD	[ ]	[ ]	[ ]

When sitting upright with NVG/HMD [ ] [ ] [ ]

If Yes, which components? ____

vii. Can you fully extend your legs in the cockpit?

Yes No

[ ] [ ]

viii. When in the flying position, do your knees or legs make contact with any cockpit components?

Yes No

[ ] [ ]

If Yes, what components? ____

ix. Do you have to slide down the seat to reach the pedals?

Yes No

[ ] [ ]

x. Do you use any additional cushions to achieve the correct seating position?

Yes No

[ ] [ ]

If Yes, what cushions (seat back, lumbar support, seat pan, other)?

____

xi. Do you use any additional cushions to improve comfort while seated?

Yes No

[ ] [ ]

If Yes, what cushions (seat back, lumbar support, seat pan, other)?

____

xii. Is your back fully supported by the seat when in the flying position?

Yes	No
[ ]	[ ]

If No, describe any unsupported areas____

xiii. Do you experience any difficulty achieving full range of control movement?

	No difficulty	Mild difficulty	Moderate difficulty	Severe difficulty	Not Applicable
Cyclic	[ ]	[ ]	[ ]	[ ]	[ ]
Collective	[ ]	[ ]	[ ]	[ ]	[ ]
Pedals	[ ]	[ ]	[ ]	[ ]	[ ]

Describe any areas of difficulty____

SECTION 3: Helmets and Night Vision Goggles

Q4. i. Please indicate which type and size of flying helmet you most commonly use:

	Small	Medium	Large `	Extra large	Other (specify)
HGU-56/P	[ ]	[ ]	[ ]	[ ]	____________
IHADSS	[ ]	[ ]	[ ]	[ ]	____________
SPH-4B	[ ]	[ ]	[ ]	[ ]	____________
Other (please specify) ________________	[ ]	[ ]	[ ]	[ ]	____________

ii. Have you ever used night vision goggles (NVGs)?

Yes	No
[ ]	[ ]

IF "NO" GO TO Q5 ON PAGE 7

iii. From your logbook, what is your total number of hours flying with NVGs to date and in the last 28 days?

Total NVG hours: __________ Total NVG hours in last 28 days: __________

iv. How long do you typically wear NVGs during a night flight?

Average hours of NVG use per night flight: __________

v. For each NVG type you have used (AN/PVS-5, AN/AVS-6), please indicate:

a. the aircraft flown while wearing that type of goggle
b. the number of flight hours using that aircraft / goggle combination
c. the date that combination was last flown
d. is the battery pack used as a counterbalance weight
e. is additional counterbalance weight <u>usually</u> used and if so how much?

<u>NVG Type</u>	<u>Aircraft</u>	<u>Flight Hours</u>	<u>Date Last Flown</u>	<u>Batteries as Balance</u>		<u>Additional Weight</u>
				Yes	No	
________	________	_________	__________	[ ]	[ ]	__________oz

SECTION 4: Neck Strain, Neck Pain, or Neck Injury

The following questions should be answered with regard to your experiences of any neck or back related symptoms:

Q5. i. Have you ever experienced neck or back pain that was <u>unrelated</u> to flying?

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

If Yes, please describe the cause and the symptoms experienced:

ii. Have you ever experienced neck or back pain that was <u>related</u> to flying?

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

If Yes, please describe the cause and the symptoms experienced:

Q6. i. Have you ever experienced neck or back pain <u>during</u> flight?

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

<u>IF "NO" GO TO Q7 ON PAGE 9</u>

ii. Please indicate the total number of episodes of neck or back pain you have experienced <u>during</u> flight:

	Neck Pain	Back Pain
1-3 episodes	[ ]	[ ]
4-10 episodes	[ ]	[ ]
More than 10 episodes	[ ]	[ ]

iii. Which of the following factors was associated with your neck pain <u>during</u> flight?

		Yes	No	Not Applicable
low G (<2G)(normal flight)	without NVGs	[ ]	[ ]	[ ]
low G	with NVG/HMD	[ ]	[ ]	[ ]
moderate G (2-4G)(maneuvering)	without NVGs	[ ]	[ ]	[ ]
moderate G	with NVG/HMD	[ ]	[ ]	[ ]
posture	without NVGs	[ ]	[ ]	[ ]
posture	with NVG/HMD	[ ]	[ ]	[ ]
Other (please specify)	___________________	[ ]	[ ]	[ ]

iv. How long (in minutes) does it usually take for you to feel neck pain <u>during</u> flight?

	0-15	16-30	31-45	46-60	61-75	75-90	>90
Without NVG/HMD	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
With NVG/HMD	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

v. Which of the following factors was associated with your back pain <u>during</u> flight?

		Yes	No	Not Applicable
low G (<2G)(normal flight)	without NVGs	[ ]	[ ]	[ ]
low G	with NVG/HMD	[ ]	[ ]	[ ]
moderate G (2-4G)(maneuvering)	without NVGs	[ ]	[ ]	[ ]
moderate G	with NVG/HMD	[ ]	[ ]	[ ]
posture	without NVGs	[ ]	[ ]	[ ]
posture	with NVG/HMD	[ ]	[ ]	[ ]
Other (please specify)	__________________	[ ]	[ ]	[ ]

vi. How long (in minutes) does it usually take for you to feel back pain <u>during</u> flight?

	0-15	16-30	31-45	46-60	61-75	75-90	>90
Without NVG/HMD	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
With NVG/HMD	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

Q7. i. Have you ever experienced neck or back pain <u>after</u> flight?

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

<u>IF "NO" GO TO Q8 ON PAGE 10</u>

ii. Please indicate the total number of episodes of neck or back pain you have experienced <u>after</u> flight:

	Neck Pain	Back Pain
1-3 episodes	[ ]	[ ]
4-10 episodes	[ ]	[ ]
More than 10 episodes	[ ]	[ ]

iii. Which of the following factors was associated with your neck pain after flight?

		Yes	No	Not Applicable
low G (<2G)(normal flight)	without NVGs	[ ]	[ ]	[ ]
low G	with NVG/HMD	[ ]	[ ]	[ ]
moderate G (2-4G)(maneuvering)	without NVGs	[ ]	[ ]	[ ]
moderate G	with NVG/HMD	[ ]	[ ]	[ ]
posture	without NVGs	[ ]	[ ]	[ ]
posture	with NVG/HMD	[ ]	[ ]	[ ]
Other (please specify)	___________________	[ ]	[ ]	[ ]

iv. Which of the following factors was associated with your back pain after flight?

		Yes	No	Not Applicable
low G (<2G)(normal flight)	without NVGs	[ ]	[ ]	[ ]
low G	with NVG/HMD	[ ]	[ ]	[ ]
moderate G (2-4G)(maneuvering)	without NVGs	[ ]	[ ]	[ ]
moderate G	with NVG/HMD	[ ]	[ ]	[ ]
posture	without NVGs	[ ]	[ ]	[ ]
posture	with NVG/HMD	[ ]	[ ]	[ ]
Other (please specify)	___________________	[ ]	[ ]	[ ]

Using the following scale, please answer the questions below:

Mild (noticeable but did not interfere with normal duties)
Moderate (difficult to concentrate on normal duties)
Severe (disrupted ability to perform normal duties)

Incapacitating (unable to perform normal duties)

Q8. Please indicate the severity of neck pain, for the <u>worst</u> episode of pain experienced:

	Mild	Moderate	Severe	Incapacitating	Not Applicable
<u>During flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]
<u>After flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]

Q9. If you commonly experience neck pain, please indicate an <u>average</u> severity of pain experienced:

	Mild	Moderate	Severe	Incapacitating	Not Applicable
<u>During flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]
<u>After flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]

Q10. i. How long did the symptoms persist for the <u>worst</u> episode of neck pain?

During flight only	[ ]
Less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
More than 4 days after flight	[ ]

ii. How long do the symptoms usually persist for the <u>average</u> episode of neck pain?

During flight only	[ ]
Less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
More than 4 days after flight	[ ]

Q11. Please indicate the severity of back pain, for the <u>worst</u> episode of pain experienced:

	Mild	Moderate	Severe	Incapacitating	Not

					Applicable
<u>During flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]
<u>After flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]

Q12. If you commonly experience back pain, please indicate an <u>average</u> severity of pain experienced:

	Mild	Moderate	Severe	Incapacitating	Not Applicable
<u>During flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]
<u>After flight</u>	[ ]	[ ]	[ ]	[ ]	[ ]

Q13. i. How long did the symptoms persist for the <u>worst</u> episode of back pain?

During flight only	[ ]
Less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
More than 4 days after flight	[ ]

ii. How long do the symptoms usually persist for the <u>average</u> episode of back pain?

During flight only	[ ]
Less than 2 hrs after flight	[ ]
2-11 hours after flight	[ ]
12-24 hours after flight	[ ]
1-4 days after flight	[ ]
More than 4 days after flight	[ ]

Q14. i. Have you ever sought treatment from a doctor or other consultant (e.g. physical therapist) for any occurrence of flight related neck or back pain?

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

IF “NO” GO TO Q15 ON PAGE 12

ii. Was the treatment sought from:

	Neck Pain	Back Pain
Military doctor	[ ]	[ ]
Civilian doctor	[ ]	[ ]
Physician’s assistant	[ ]	[ ]
Physical therapist	[ ]	[ ]
Chiropractor	[ ]	[ ]

iii. Were you given any treatment for your neck or back pain?

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

If Yes, please describe briefly the treatment you received (including medication, OTC medication, :

Q15. i. Have you ever been grounded as a result of flight-related neck pain?

Yes	No
[ ]	[ ]

If Yes, please indicate for how long you were grounded:

More than 1 month	[ ]
3-4 weeks	[ ]
1-2 weeks	[ ]
Less than 1 week	[ ]
Currently grounded	[ ]
Never	[ ]

ii. If you are currently grounded due to neck pain, please state the length of time you have been grounded for so far:

Length of current grounding period: __________

iii. Does your neck pain affect your ability to perform mission-related tasks?

Yes	No	N/A
[ ]	[ ]	[ ]

If Yes, describe effect_______________________________________

iv. Have you ever been grounded as a result of flight-related back pain?

Yes	No
[ ]	[ ]

If Yes, please indicate for how long you were grounded:

More than 1 month	[ ]
3-4 weeks	[ ]
1-2 weeks	[ ]
Less than 1 week	[ ]
Currently grounded	[ ]
Never	[ ]

v. If you are currently grounded due to back pain, please state the length of time you have been grounded for so far:

Length of current grounding period: __________

vi. Does your back pain affect your ability to perform mission-related tasks?

Yes	No	N/A
[ ]	[ ]	[ ]

If Yes, describe effect_______________________________________

vii. Have you ever taken any action in order to minimize or avoid flight-related neck or back pain?

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

If Yes, please describe the type of action taken and if the action taken was effective:

____

viii. Does your neck or back pain affect leisure activities (e.g. sleep, driving, sports, hunting)

	Yes	No
Neck Pain	[ ]	[ ]
Back Pain	[ ]	[ ]

If Yes, please describe which activities and how they are affected:

____

SECTION 5: Study Technicians will complete the following section Subject number ________

Q16.	i.	Stature:	______ft ______in
	ii.	Weight:	______lbs
		Sitting height	______inches
		Thumb tip reach	______inches
		Functional leg length	______inches
		Buttock knee length	______inches
		Thigh clearance	_______inches
		Head circumference	_______inches
		Neck circumference (base)	_______inches

Appendix B.

Data collection forms.

Table B-1.
Relationship of age to flying hours.

	Total flying hours	Flying hours last 28 days	Total NVG hours	NVG hours last 28 days
Age	**G=0.432 P=<0.001 N=83**	G=-0.013 P=0.903 N=84	G=0.046 P=0.711 N=72	G=0.054 P=0.681 N=72

Table B-2.
Anthropometric measurements and ergonomic considerations.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
3i Ability to sit upright in full ALSE	6,N= 85	χ2=8.329 p=0.215	χ2=6.112 p=0.411	χ2=4.751 p=0.576	χ2=7.508 p=0.276	χ2=3.896 p=0.691	χ2=8.898 p=0.179	χ2=4.235 p=0.645	χ2=3.297 p=0.771	χ2=4.950 p=0.550
3ii Comfort rating in aircraft	N=83	G=-0.002 p=0.986	G=0.210 p=0.073	G=0.028 p=0.804	G=0.055 p=0.603	G=0.077 p=0.479	G=0.112 p=0.295	G=0.051 p=0.659	G=0.010 p=0.929	**G=0.324 p=0.030**
3 iv. Slouch to fit in aircraft	3,N= 82	χ2=0.125 p=0.989	χ2=1.576 p=0.665	χ2=0.020 p=0.999	χ2=1.073 p=0.783	χ2=0.955 p=0.812	**χ2=10.330 p=0.016**	χ2=0.993 p=0.803	χ2=1.830 p=0.608	χ2=1.245 p=0.742
3v Slouch with NVG	3,N= 76	χ2=0.756 p=0.860	χ2=1.934 p=0.586	χ2=1.924 p=0.588	χ2=0.841 p=0.840	χ2=1.787 p=0.618	**χ2=10.263 p=0.016**	χ2=2.367 p=0.500	χ2=1.146 p=0.766	χ2=0.804 p=0.849
3vi headstrike, no NVG	6,N= 83	χ2=2.472 p=0.872	χ2=5.102 p=0.531	χ2=7.193 p=0.303	χ2=7.106 p=0.311	**χ2=13.328 p=0.038**	χ2=6.877 p=0.332	χ2=4.197 p=0.467	χ2=3.509 p=0.743	χ2=2.933 p=0.817
3vi headstrike with NVG	6,N= 83	χ2=3.112 p=0.795	χ2=5.786 p=0.448	χ2=3.042 p=0.804	χ2=9.363 p=0.154	χ2=10.829 p=0.094	χ2=2.244 p=0.896	χ2=8.927 p=0.178	χ2=4.800 p=0.570	χ2=2.626 p=0.854
3x Cushions for seating position	6,N= 80	χ2=1.262 p=0.738	χ2=4.820 p=0.185	χ2=1.174 p=0.759	χ2=2.932 p=0.402	χ2=2.165 p=0.539	χ2=3.131 p=0.372	χ2=4.778 p=0.189	χ2=4.145 p=0.246	**χ2=80.97 p=0.044**
3xi Cushions for seat	3,N= 83	χ2=1.903 p=0.593	χ2=2.481 p=0.479	χ2=1.190 p=0.756	χ2=2.366 p=0.500	χ2=0.113 p=0.990	χ2=1.673 p=0.643	χ2=6.363 p=0.095	χ2=2.362 p=0.501	χ2=3.475 p=0.324

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
comfort										
3xii back fully supported in flying position	6,N= 84	χ2=8.741 p=0.189	χ2=5.417 p=0.492	χ2=8.615 p=0.196	χ2=8.776 p=0.187	χ2=5.838 p=0.442	χ2=5.846 p=0.441	χ2=3.859 p=0.696	χ2=5.839 p=0.441	χ2=8.067 p=0.233

Table B-3.

Anthropometric considerations and cockpit integration. Pilots only.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
3i Ability to sit upright in full ALSE	3,N= 54	χ2=3.868 p=0.276	χ2=5.317 p=0.150	χ2=2.369 p=0.499	χ2=5.391 p=0.145	χ2=2.131 p=0.	χ2=7.590 p=0.055	χ2=0.103 p=0.992	χ2=1.826 p=0.609	χ2=4.828 p=0.185
3ii Comfort rating in cockpit	N=54	G=0.004 p=0.971	**G=0.409 p=<0.001**	G=-0.063 p=0.651	G=0.059 p=0.675	G=0.178 p=0.223	G=0.147 p=0.284	G=0.035 p=0.787	G=0.061 p=0.651	**G=0.382 p=0.013**
3iii Cyclic reach	N=54	G=-0.384 p=0.260	G=0.368 p=0.430	G=-0.508 p=0.101	G=-0.314 p=0.437	G=--0.399 p=0.263	G=-0.456 P=0.096	G=-0.118 p=0.758	G=0.189 p=0.509	G=0.075 p=0.889
3iii Collective reach	N=54	G=-0.384 p=0.260	**G=1.000 p=0.015**	G=-0.260 p=0.297	G=-0.634 p=0.097	G=0.183 p=0.540	G=-0.452 p=0.099	G=-0.269 p=0.414	G=0.216 p=0.453	**G=1.000 p=0.023**
3iii Pedals reach	N=54	G=0.135 p=0.824	G=-0.333 P=0.654	G=-0.195 P=0.471	G=-0.671 p=0.169	G=0.354 p=0.483	G=-0.139 p=0.699	G=0.173 p=0.749	G=0.425 p=0.328	G=-0.576 p=0.475
3 iv. Slouch to fit in cockpit	3,N= 54	χ2=0.521 p=0.914	χ2=2.180 p=0.536	χ2=1.691 p=0.639	χ2=1.325 p=0.723	χ2=1.758 p=0.624	χ2=2.714 p=0.438	χ2=0.166 p=0.983	χ2=1.131 p=0.770	χ2=2.899 p=0.407
3v Slouch with NVG, cockpit	6,N= 50	χ2=3.120 p=0.794	χ2=6.681 p=0.351	χ2=6.812 p=0.339	χ2=3.982 p=0.686	χ2=7.360 p=0.289	χ2=2.830 p=0.830	χ2=5.541 p=0.476	χ2=2.840 p=0.829	χ2=5.986 p=0.425
3vi Cockpit	3,	χ2=0.890	χ25.187	χ2=2.184	χ2=1.772	χ2=0.651	χ2=1.510	χ2=0.478	χ2=2.289	χ2=0.615

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
headstrike, no NVG	N=53	p=0.828	p=0.159	p=0.535	p=0.621	p=0.885	p=0.680	p=0.924	p=0.515	p=0.893
3vi Cockpit headstrike with NVG	6, N=53	$\chi2$=2.972 p=0.812	$\chi2$=4.734 p=0.578	$\chi2$=3.833 p=0.699	$\chi2$=7.241 p=0.299	$\chi2$=5.761 p=0.450	$\chi2$=1.778 p=0.939	$\chi2$=7.303 p=0.294	$\chi2$=3.314 p=0.768	$\chi2$=7.021 p=0.319
3vii Ability to fully extend legs	3, N=54	$\chi2$=7.061 p=0.070	$\chi2$=6.179 p=0.103	$\chi2$=6.826 p=0.078	$\chi2$=0.506 p=0.918	$\chi2$=0.883 p=0.829	$\chi2$=6.212 p=0.102	$\chi2$=2.359 p=0.501	$\chi2$=2.380 p=0.497	$\chi2$=2.820 p=0.420
3viii lower limb strike against cockpit components	3, N=54	$\chi2$=0.919 p=0.821	$\chi2$=1.338 p=0.720	$\chi2$=2.152 p=0.541	$\chi2$=1.975 p=0.578	$\chi2$=0.321 p=0.956	$\chi2$=0.890 p=0.828	$\chi2$=4.848 p=0.183	$\chi2$=0.592 p=0.898	$\chi2$=3.759 p=0.289
3ix Slide down to reach pedals	N=54	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
3x Cushions for seating position	3, N=54	$\chi2$=1.532 p=0.675	$\chi2$=3.154 p=0.368	$\chi2$=5.577 p=0.134	$\chi2$=1.481 p=0.687	$\chi2$=1.238 p=0.744	$\chi2$=2.383 p=0.497	$\chi2$=2.348 p=0.503	$\chi2$=3.036 p=0.386	**$\chi2$=7.846 p=0.049**
3xi Cushions for seat comfort		$\chi2$=1.657 p=0.646	$\chi2$=2.681 p=0.443	$\chi2$=3.527 p=0.317	$\chi2$=0.475 p=0.924	$\chi2$=0.080 p=0.994	$\chi2$=2.795 p=0.424	$\chi2$=5.488 p=0.139	$\chi2$=3.283 p=0.350	$\chi2$=2.310 p=0.511
3xii back fully supported in flying position	3, N=54	$\chi2$=0.818 p=0.845	$\chi2$=3.295 p=0.348	$\chi2$=2.846 p=0.416	$\chi2$=4.418 p=0.220	$\chi2$=5.122 p=0.163	$\chi2$=2.560 p=0.465	$\chi2$=5.688 p=0.128	$\chi2$=5.300 p=0.151	$\chi2$=6.284 p=0.099
3xiii Cyclic control movement	N=54	G=0.216 P=0.360	G=0.452 p=0.076	G=-0.207 P=0.377	G=-0.168 P=0.517	G=0.109 p=0.690	G=0.119 p=0.594	G=0.171 p=0.502	**G=0.501 p=0.023**	G=0.420 p=0.180
3xiii Collective control movement	N=54	G=-0.307 P=0.406	G=1.000 p=0.144	G=-0.475 P=0.354	G=-0.342 P=0.646	G=0.354 p=0.483	G=-0.667 p=0.196	G=0.514 p=0.269	G=0.111 p=0.839	G=1.000 p=0.154
3xiii Pedals control movement	N=54	G=0.431 p=0.406	G=1.000 p=0.068	G=-0.288 P=0.418	G=-0.302 P=0.506	G=1.000 p=0.064	G=-0.038 p=0.936	G=0.143 p=0.697	G=0.612 p=0.146	G=-0.072 p=0.900

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference

Table B-4.

Anthropometric measurements and cabin integration. Rear crew only.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
3i Ability to sit upright in full ALSE	Df=6 N=28	χ2=5.010 p=0.543	χ2=6.751 p=0.345	χ2=4.395 p=0.623	χ2=5.310 p=0.505	χ2=3.300 p=0.770	χ2=7.800 p=0.253	χ2=9.928 p=0.128	χ2=4.647 p=0.590	χ2=1.246 p=0.536 (df=2)
3ii Comfort rating in seat	N=27	G=0.171 p=0.368	G=-0.341 p=0.168	G=0.324 p=0.111	G=0.298 p=0.083	G=0.089 p=0.609	G=0.100 p=0.612	G=0.059 p=0.809	G=-0.050 p=0.783	G=-0.381 p=0.387
3 iv. Slouch to fit in rear cabin	df=3, N=26	X=22.345 p=0.504	χ2= 1.857 p=0.603	χ2=1.052 p= 0.789	χ2=0.580 p=0.901	**χ2= 8.244 p=0.041**	**χ2=10.520 p=0.015**	χ2=0.851 p=0.837	χ2=1.144 p=0.767	χ2= 0.013 p=1.000 (df= 1)
3v Slouch with NVG, rear cabin	df=3, N=28	χ2=6.688 p=0.083	χ2=1.952 p=0.582	χ2=2.625 p=0.453	χ2=4.287 p=0.232	**χ2=12.080 p=0.007**	**χ2=15.469 9=0.001**	χ2=3.369 p=0.338	χ2=1.407 p=0.704	χ2=0.104 p=0.640 (df=1)
3vi Cabin headstrike, no NVG	df=6, N=28	χ2=7.292 p=0.295	χ2=4.795 p=0.570	χ2=4.760 p=0.575	χ2=11.883 p=0.065	χ2=11.197 p=0.082	χ2=5.364 p=0.498	χ2=3.335 p=0.766	χ2=6.773 p=0.342	χ2=1.867 p=0.393 (df=2)
3vi Cabin headstrike with NVG	df=6, N=28	χ2=12.125 p=0.059	χ2=6.924 p=0.328	χ2=8.793 p=0.186	χ2=6.603 p=0.359	χ2=8.206 p=0.223	χ2=6.050 p=0.418	χ2=4.785 p=0.572	χ2=9.271 p=0.159	χ2=1.436 p=0.488
3x Cushions for rear seating position	df=6 N=27	χ2=10.232 p=0.115	χ2=8.718 p=0.190	χ2=9.488 p=0.148	χ2=5.806 p=0.445	χ2=5.712 p=0.456	χ2=12.505 p=0.052	χ2=5.650 p=0.464	**χ2=14.391 p=0.026**	χ2=0.909 p=0.635
3xi Cushions for rear seat comfort	Df=6 N=28	χ2=7.013 p=0.320	χ2=2.164 p=0.904	χ2=4.236 p=0.645	χ2=3.798 p=0.704	χ2=3.015 p=0.807	χ2=2.357 p=0.884	χ2=6.173 p=0.404	χ2=2.795 p=0.834	χ2=2.154 p=0.341
3xii back fully supported in	df=6 N=28	χ2=6.708 p=0.349	χ2=5.471 p=0.485	χ2=6.291 p=0.391	χ2=4.783 p=0.572	χ2=3.850 p=0.697	χ2=3.150 p=0.790	χ2=4.326 p=0.633	χ2=5.274 p=0.509	χ2= 0.359 p=0.836 (df=2)

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
flying position										

Neck symptoms

Table B-5.
Neck symptoms and anthropometric parameters

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ.	Neck circ
5i Neck pain unrelated to flying	df=3, N=79	χ2=1.592 p=0.661	χ2=1.414 p=0.702	χ2=1.125 p=0.771	χ2=1.392 p=0.707	**χ2=13.948 p=0.003**	χ2=3.434 p=0.329	χ2=0.416 p=0.937	χ2=1.781 p=0.619	χ2=2.899 p=0.408
5ii Neck pain related to flying (all)	df=3 N=77	χ2=0.482 p=0.923	χ2=2.755 p=0.431	χ2=3.155 p=0.368	χ2=2.099 p=0.552	**χ2=9.285 p=0.026**	χ2=3.496 p=0.321	χ2=0.100 p=0.992	χ2=2.087 p=0.555	χ2=2.285 p=0.515
5ii Neck pain related to flying (pilot)	df=3 N=50	χ2=0.982 p=0.806	χ2=0.770 p=0.857	χ2=0.999 p=0.802	χ2=6.777 p=0.079	χ2=4.403 p=0.221	χ2=0.762 p=0.858	χ2=4.604 p=0.203	χ2=1.407 p=0.704	χ2=2.790 p=0.425
5ii Neck pain related to flying (rear)	df=3 N=25	χ2=3.860 p=0.277	**χ2=7.931 p=0.047**	**χ2=7.920 p=0.048**	χ2=5.469 p=0.141	χ2=4.741 p=0.192	χ2=7.077 p=0.069	**χ2=10.032 p=0.018**	χ2=1.563 p=0.668	χ2=1.023 p=0.453 (df=1)
6i Neck pain during flying (all)	df=3 N=78	χ2=2.507 p=0.474	χ2=1.093 p=0.779	**χ2=7.865 p=0.049**	χ2=0.876 p=0.831	χ2=5.147 p=0.161	χ2=1.572 p=0.666	χ2=2.631 p=0.452	χ2=4.772 p=0.189	χ2=2.391 p=0.495
6i Neck pain during flying (pilot)	df=3 N=52	χ2=1.917 p=0.590	χ2=0.377 p=0.945	χ2=6.171 p=0.104	χ2=2.810 p=0.422	χ2=3.979 p=0.264	χ2=0.836 p=0.841	**χ2=9.442 p=0.024**	χ2=2.063 p=0.560	χ2=2.395 p=0.495
6i Neck pain during flying (rear)	df=3 N=24	χ2=1.697 p=0.638	χ2=3.429 p=0.330	χ2=4.089 p=0.252	χ2=2.159 p=0.540	χ2=3.479 p=0.323	χ2=5.867 p=0.118	χ2=4.606 p=0.203	χ2=1.685 p=0.640	χ2=0.727 p=0.554 (df=1)

Table B-6.
Neck symptoms and non-anthropometric parameters.

Question	Crew position	Age	Total flying hrs	Hrs last 28 days	Total NVG hours	NVG hours last 28 days	NVG counterbalance weight
5i Neck pain unrelated to flying	$\chi2(2,N=79)=1.090$ p=0.580	G=0.211 p=0.203 N=78	G=0.011 p=0.942 N=76	G=-0.066 P=0.682 N=77	G=- 0.081 p=0.637 N=69	G=0.132 p=0.441 N=69	G=0.113 p=0.567 N=49
5ii Neck pain related to flying (all)	$\chi2(4,N=79)=1.649$ p=0.800	**G=0.328 p=0.042 N=77**	**G=0.433 p=0.002 N=74**	G=0.202 P=0.198 N=75	G=0.266 P=0.090 N=69	G=0.229 p=0.113 N=69	G=0.237 p=0.713 N=49
6i Neck pain during flying (all)	$\chi2(4,N=79)=5.750$ p=0.219	**G=0.412 p=0.008 N=78**	**G=0.512 p=<0.001 N=75**	G=0.073 p=0.645 N=76	**G=0.391 P=0.014 N=69**	G=0.225 p=0.174 N=69	G=-0.068 p=0.764 N=49

Table B-7.
Contributory factors and anthropometry (neck). Contribution of flight parameters and anthropometric measurements to neck pain during flight.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
6ii Neck pain episodes (all)	N=49	G=-0.243 p=0.146	G=0.115 p=0.596	G=-0.035 p=0.839	G=-0.170 p=0.367	G=-0.254 p=0.144	G=-0.204 p=0.226	G=-0.147 p=0.367	G=0.038 p=0.830	G=0.038 p=0.909
6ii Neck pain episodes (pilot)	N=29	G=-0.376 p=0.057	G=0.135 p=0.592	G=-0.219 p=0.285	G=-0.188 p=0439	G=-0.198 p=0.407	**G=-0.490 p=0.004**	**G=-0.399 p=0.035**	G=-0.081 p=0.720	G=0.206 p=0.567
6iii Neck pain episodes (rear)	N=19	G=0.013 p=0.963	G=0.077 p=0.855	G=0.0195 p=0.538	G=-0.014 p=0.964	G=-0.282 p=0.275	G=0.280 p=0.364	G=0.016 p=0.967	G=0.278 p=0.317	G=-1.000 p=0.120
6iii low G	df=6	$\chi2=3.846$	$\chi2=5.012$	$\chi2=6.523$	$\chi2=1.767$	**$\chi2=13.910$**	$\chi2=9.694$	$\chi2=12.021$	$\chi2=4.090$	$\chi2=4.200$

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
(<2G) no NVG (all)	N=55	p=0.698	p=0.542	p=0.367	p=0.940	**p=0.031**	p=0.138	p=0.061	p=0.664	p=0.380 (df=4)
6iii low G (<2G) no NVG (pilot)	df=6 N=34	χ2=3.265 p=0.775	χ2=7.004 p=0.320	χ2=2.516 p=0.867	χ2=9.435 p=0.151	χ2=11.216 p=0.082	χ2=6.812 p=0.339	χ2=11.256 p=0.081	χ2=4.471 p=0.613	χ2=3.572 p=0.467
6iii low G (<2G) no NVG (rear)	df=6 N=21	χ2=6.823 p=0.338	χ2=1.307 p=0.860	χ2=9.791 p=0.134	χ2=8.824 p=0.184	χ2=6.585 p=0.361	χ2=10.235 p=0.115	**χ2=14.711 p=0.023**	χ2=7.917 p=0.244	χ2=1.382 p=0.501 (df=2)
6iii low G with NVG (all)	df=6 N=56	χ2=7.293 p=0.295	χ2=4.808 p=0.569	χ2=7.497 p=0.277	χ2=0.900 p=0.989	χ2=10.192 p=0.117	χ2=9.684 p=0.139	χ2=5.588 p=0.471	χ2=2.765 p=0.838	χ2=1.389 p=0.846 (df=4)
6iii low G with NVG (pilot)	df=6 N=35	χ2=4.287 p=0.638	χ2=7.541 p=0.274	χ2=5.027 p=0.540	χ2=7.446 p=0.282	χ2=9.057 p=0.170	χ2=5.847 p=0.441	χ2=8.773 p=0.187	χ2=5.874 p=0.437	χ2=3.130 p=0.536 (df=4)
6iii low G with NVG (rear)	df=6 N=20	χ2=8.733 p=0.189	χ2=2.345 p=0.673	χ2=7.530 p=0.275	χ2=6.700 p=0.349	χ2=2.556 p=0.862	χ2=4.754 p=0.576	χ2=9.167 p=0.164	χ2=5.852 p=0.440	χ2=1.481 p=0.477 (df=2)
6iii mod G (2-4G) no NVG (all)	df=6 N=49	χ2=7.578 p=0.271	χ2=5.626 p=0.466	**χ2=16.338 p=0.012**	χ2=5.165 p=0.523	χ2=12.095 p=0.060	χ2=7.233 p=0.300	χ2=10.592 p=0.102	χ2=1.517 p=0.958	χ2=5.892 p=0.207 (df=4)
6iii mod G (2-4G) no NVG (pilot)	df=6 N=29	χ2=5.121 p=0.528	χ2=6.525 p=0.367	χ2=10.467 p=0.106	χ2=10.568 p=0.103	χ2=8.418 p=0.209	χ2=7.860 p=0.249	χ2=9.438 p=0.150	χ2=3.961 p=0.682	χ2=6.655 p=0.155 (df=4)
6iii mod G (2-4G) no NVG (rear)	df=6 N=20	χ2=9.743 p=0.136	χ2=1.426 p=0.840 (df=4)	χ2=9.122 p=0.167	χ2=9.762 p=0.135	χ2=6.077 p=0.415	χ2=4.418 p=0.620	χ2=10.163 p=0.118	χ2=10.825 p=0.094	χ2=1.389 p=0.499 (df=2)
6iii mod G with NVG (all)	df=6 N=51	χ2=9.060 p=0.170	χ2=8.703 p=0191	**χ2=14.291 p=0.027**	χ2=6.201 p=0.401	χ2=10.411 p=0.108	χ2=4.950 p=0.550	χ2=9.002 p=0.173	χ2=2.657 p=0.851	χ2=2.153 p=0.708 (df=4)
6iii mod G with NVG (pilot)	df=6 N=30	χ2=5.598 p=0.470	χ2=10.703 p=0.098	χ2=9.632 p=0.141	χ2=9.095 p=0.168	χ2=8.103 p=0.231	χ2=4.643 p=0.590	χ2=10.518 p=0.104	χ2=4.106 p=0.662	χ2=2.695 p=0.610 (df=4)
6iii mod G with NVG (rear)	df=6 N=20	**χ2=14.200 p=0.027**	χ2=1.518 p=0.823 (df=4)	χ2=10.505 p=0.105	χ2=12.333 p=0.055	χ2=3.158 p=0.789	χ2=4.054 p=0.669	χ2=6.972 p=0.323	χ2=4.844 p=0.564	χ2=0.278 p=0.870 (df=2)
6iii Posture no NVG (all)	df=6 N=54	χ2=2.524 p=0.866	χ2=3.455 p=0.750	χ2=3.371 p=0.761	χ2=2.395 p=0.880	χ2=5.174 p=0.522	χ2=4.032 p=0.672	χ2=3.161 p=0.788	χ2=1.426 p=0.964	χ2=1.046 p=0.903

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
										(df=4)
6iii Posture no NVG (pilot)	df=6 N=32	χ2=0.559 p=0.997	χ2=4.881 p=0.559	χ2=2.571 p=0.860	χ2=9.073 p=0.170	χ2=3.688 p=0.719	χ2=5.188 p=0.520	χ2=6.957 p=0.325	χ2=1.478 p=0.961	χ2=1.772 p=0.778 (df=4)
6iii Posture no NVG (rear)	df=6 N=22	χ2=5.844 p=0.441	χ2=3.712 p=0.716	χ2=6.428 p=0.377	χ2=4.452 p=0.616	χ2=3.274 p=0.774	χ2=6.163 p=0.405	χ2=5.867 p=0.438	χ2=2.865 p=0.826	χ2=0.825 p=0.662 (df=2)
6iii Posture with NVG (all)	df=6 N=56	χ2=1.370 p=0.968	χ2=5.408 p=0.493	χ2=4.739 p=0.578	χ2=4.742 p=0.577	χ2=2.406 p=0.879	χ2=4.775 p=0.573	χ2=3.675 p=0.721	χ2=4.472 p=0.613	χ2=3.458 p=0.484 (df=4)
6iii Posture with NVG (pilot)	df=6 N=33	χ2=4.453 p=0.616	χ2=7.063 p=0.315	χ2=8.428 p=0.208	χ2=7.491 p=0.278	χ2=2.231 p=0.897	χ2=6.659 p=0.354	χ2=9.884 p=0.130	χ2=3.409 p=0.756	χ2=5.312 p=0.257
6iii Posture with NVG (rear)	df=6 N=23	χ2=3.920 p=0.687	**χ2=14.439 p=0.025**	χ2=6.190 p=0.402	χ2=3.742 p=0.712	χ2=5.987 p=0.425	χ2=5.111 p=0.530	χ2=11.074 p=0.086	**χ2=13.133 p=0.041**	χ2=0.608 p=0.738 (df=2)

<u>Table B-8.</u>

Contributory factors and non-anthropometric measures (neck). Influence of crew position, age and flying hours to neck pain on reports of contributory factors to neck pain during flight.

Question	Crew position	Age	Total flying hours	Flying hrs last 28 days	Total NVG hours	NVG hrs last 28 days	NVG Counterbalance weight
6ii Neck pain episodes (all)	χ2(6,N=49)=4.2872 p=0.639	G=-0.081 p=0.681 N=49	G=0.106 p=0.568 N=48	G=0.003 p=0.984 N=48	G=0.057 p=0.733 N=48	G=0.005 p=0.974 N=48	G=0.126 p=0.564 N=33
6iii low G (<2G) no NVG (all)	χ2(2,N=55)=0.125 p=0.940	G=0.173 p=0.295 N=55	**G=0.368 p=0.007 N=54**	G=0.093 p=0.532 N=55			
6iii low G with NVG (all)	χ2(4,N=56)=1.017 p=0.907	G=0.135 p=0.455 N=56	**G=0.530 p=<0.001 N=54**	G=0.230 p=0.153 N=55	**G=0.366 p=0.039 N=51**	G=0.025 p=0.894 N=51	G=0.140 p=0.515 N=37
6iii mod G (2-	χ2(2,N=49)=0.859	G=-0.054	G=0.202	G=0.142			

Question	Crew position	Age	Total flying hours	Flying hrs last 28 days	Total NVG hours	NVG hrs last 28 days	NVG Counterbalance weight
4G) no NVG (all)	p=0.651	p=0.766 N=49	p=0.195 N=48	p=0.331 N=49			
6iii mod G with NVG (all)	χ2(4,N=51)=3.575 p=0.467	G=0.073 p=0.660 N=51	G=0.274 p=0.068 N=49	G=0.187 p=0.240 N=50	G=0.193 p=0.270 N=46	G=-0.047 p=0.795 N=46	G=-0.062 p=0.767 N=32
6iii Posture no NVG (all)	χ2(2,N=54)=5.514 p=0.063	G=0.208 p=0.254 N=54	**G=0.454** **p=0.001** **N=53**	G=0.197 p=0.196 N=54			
6iii Posture with NVG (all)	χ2(4,N=57)=3.653 p=0.113	G=0.137 p=0.483 N=57	**G=0.576** **p=<0.001** **N=55**	G=0.134 p=0.443 N=56	**G=0.510** **p=0.005** **N=51**	G=-0.125 p=0.569 N=51	G=-0.336 p=0.121 N=35

Table B-9.

Post-flight contributory factors and anthropometry (neck). Contribution of flight parameters and anthropometric measurements to neck pain after flying.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
7i Neck pain after flying	df=3 N=75	χ2=0.698 p=0.874	χ2=3.984 p=0.263	χ2=5.001 p=0.172	χ2=0.225 p=0.973	χ2=7.084 p=0.069	χ2=1.666 p=0.645	χ2=1.065 p=0.785	χ2=2.460 p=0.483	χ2=0.320 p=0.852
7ii neck episodes after flight	N=47	G=-0.150 p=0.436	G=0.193 p=0.397	G=-0.085 p=0.629	G=-0.139 p=0.507	G=-0.008 p=0.965	G=-0.081 p=0.658	G=-0.158 P=0.392	G=-0.043 P=0.827	G=0.344 p=0.260
7iii low G no NVG (all)	df=6 N=54	χ2=0.993 p=0.986	χ2=2.646 p=0.852	χ2=4.385 p=0.625	χ2=6.311 p=0.389	χ2=3.383 p=0.759	χ2=9.565 p=0.144	**χ2=15.761** **p=0.015**	χ2=6.932 p=0.254	χ2=2.419 p=0.659 (df=4)
7iii low G with NVG (all)	df=6 N=54	χ2=7.806 p=0.253	χ2=4.221 p=0.647	χ2=7.451 p=0.281	χ2=10.148 p=0.119	χ2=12.369 p=0.054	χ2=5.325 p=0.503	**χ2=14.640** **p=0.023**	χ2=3.676 p=0.720	χ2=3.786 p=0.436 (df=4)

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
7iii mod G no NVG (all)	df=6 N=49	χ2=5.280 p=0.508	χ2=4.827 p=0.566	χ2=10.593 p=0.102	χ2=4.709 p=0.582	χ2=2.095 p=0.911	χ2=1.594 p=0.953	χ2=10.285 p=0.113	χ2=3.486 p=0.746	χ2=4.862 p=0.302 (df=4)
7iii mod G with NVG)all)	df=6 N=49	χ2=7.345 p=0.290	χ2=8.167 p=0.226	χ2=5.855 p=0.440	χ2=5.327 p=0.503	χ2=7.612 p=0.268	χ2=3.810 p=0.702	χ2=9.937 p=0.127	χ2=1.294 p=0.972	χ2=4.616 p=0.329 (df=4)
7iii posture no NVG (all)	df=6 N=56	χ2=2.067 p=0.913	χ2=4.113 p=0.661	χ2=3.247 p=0.777	χ2=8.772 p=0.187	χ2=2.345 p=0.885	χ2=4.245 p=0.644	χ2=5.162 p=0.523	χ2=2.805 p=0.857	χ2=0.924 p=0.921 (df=4)
7iii posture with NVG (all)	df=6 N=55	χ2=2.718 p=0.843	χ2=5.546 p=0.476	χ2=4.114 p=0.661	χ2=7.637 p=0.266	χ2=2.317 p=0.888	χ2=8.118 p=0.230	χ2=3.844 p=0.698	χ2=2.103 p=0.910	χ2=2.564 p=0.633

Table B-10.

Post-flight contributory factors and non-anthropometric parameters (neck). Contribution of flight parameters and age, crew position and flying hours to neck pain after flying.

Question	Crew position	Age	Total flying hours	Flying hrs last 28 days	Total NVG hours	NVG hrs last 28 days	NVG Counterbalance weight
7i Neck pain after flight	χ2(2, N=75)=0.174 p=0.917	χ2(8,N=76)=13.559 p=0.094	**G=0.406 p=0.004 N=72**	G=0.096 p=0.546 N=73	G=0.307 p=0.063 N=64	G=0.258 p=0.145 N=64	G=0.276 p=0.189 N=47
7ii neck episodes after flight	χ2(6,N=47)=5.603 p=0.469	G=0.292 p=0.135 N=47	G=0.071 p=0.699 N=46	**G=-0.359 P=0.034 N=46**	G=-0.161 p=0.381 N=44	**G=-0.338 p=0.044 N=44**	G=0.231 p=0.355 N=33
7iii low G no NVG to neck pain after flight	χ2(2,N=54)=3.825 p=0.148	χ2(6,N=37)=9.151 p=0.165	G=0.204 p=0.116 N=53	G=0.117 p=0.378 N=54			

7iii low G with NVG	**χ2(2,N=54)=6.148 p=0.046**	χ2(5,N=37)=4.864 p=0.433	**G=0.325 p=0.018 N=53**	G=0.262 p=0.079 N=54	G=0.167 p=0.311 N=49	G=0.196 p=0.273 N=49	G=-0.016 p=0.939 N=36
7iii Mod G no NVG	χ2(2.N=49)=0.476 p=0.788	χ2(5,N=29)=4.664 p=0.458	G=0.053 p=0.706 N=48	G=0.145 p=0.291 N=49			
7iii Mod G NVG	χ2(2.N=49)=0.963 p=0.618	χ2(4,N=28)=0.992 p=0.911	G=0.153 p=0.297 N=48	G=0.264 p=0.071 N=49	G=0.042 p=0.809 N=44	G=0.123 p=0.485 N=44	G=-0.015 p=0.940 N=31
7iii Posture no NVG	χ2(2,N=56)=2.152 p=0.341	χ2(5,N=40)=2.872 p=0.720	G=0.201 p=0.170 N=55	G=0.028 p=0.856 N=56			
7iii Posture with NVG	χ2(2,N=55)=2.794 p=0.247	χ2(4,N=38)=2.259 p=0.688	G=0.301 p=0.062 N=54	G=0.114 p=0.505 N=55	G=0.229 p=0.208 N=49	G=0.188 p=0.337 N=49	G=-0.382 p=0.081 N=34

Table B-11.

Anthropometric measurements and neck pain severity.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
6iv Duration of neck pain no NVG during flight(all)	N=46	G=-0.42 p=0.830	G=-0.237 p=0.256	G=0.225 p=0.173	G=0.126 p=0.480	G=-0.31 p=0.872	G=-0.140 p=0.448	G=-0.096 p=0.590	G=-0.061 p=0.715	G=0.455 p=0.157
6iv Duration of neck pain with NVG during flight(all)	N=53	G=-0.88 p=0.553	G=-0.280 p=0.097	G=0.159 p=0.306	G=-0.101 p=0.528	G=-0.94 P=0.497	G=-0.109 p=0.436	G=-0.013 p=0.920	G=-0.095 p=0.523	G=0.098 p=0.722
7ii Episodes of neck pain experienced after flight	N=47	G=-0.150 p=0.436	G=0.193 p=0.397	G=-0.085 p=0.629	G=-0.139 p=0.507	G=-0.008 p=0.965	G=-0.081 p=0.658	G=-0.158 p=0.392	G=-0.043 p=0.827	G=0.344 p=0.260
8 Severity of worst neck pain during flight (all)	N=53	G=0.158 p=0.384	G=0.078 p=0.704	G=0.231 p=0.119	G=0.201 p=0.285	G=-0.090 p=0.636	G=0.108 p=0.509	G=-0.102 p=0.532	G=-0.183 p=0.286	G=0.162 p=0.584

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
8 Severity of worst neck pain after flying	N=53	G=0.130 p=0.469	G=-0.095 p=0.618	G=0.268 p=0.099	G=-0.077 p=0.676	G=-0.003 p=0.985	G=0.083 p=0.609	G=-0.144 p=0.321	G=-0.013 p=0.940	G=0.290 p=0.269
9 Severity of average neck pain during flight (all)	N=46	G=-0.148 p=0.476	G=0.212 p=0.400	G=0.160 p=0.364	G=-0.061 p=0.761	**G=-0.456 p=0.029**	G=-0.112 p=0.599	G=-0.077 p=0.711	G=-0.156 p=0.471	G=0.078 p=0.832
9 Severity of average neck pain after flight	N=44	G=0.029 p=0.894	G=0.204 p=0.424	**G=0.354 p=0.048**	G=-0.079 p=0.700	G=-0.171 p=0.456	G=0.164 p=0.448	G=-0.1589 p=0.392	G=0.002 p=0.991	G=0.101 p=0.773
10i Duration of worst episode of neck pain	N=55	G=0.142 p=0.340	G=-0.106 p=0.518	G=0.185 p=0.210	G=0.007 p=0.964	G=-0.015 p=0.915	G=0.041 p=0.784	G=-0.118 p=0.337	G=-0.059 p=0.667	G=-0.154 p=0.483
10ii Duration of average episode of neck pain	N=57	G=0.206 p=0.162	G=-0.066 p=0.660	G=0.159 p=0.288	G=-0.106 p=0.475	G=0.065 p=0.660	G=0.174 p=0.174	G=0.022 p=0.867	G=0.054 p=0.672	G=-0.163 p=0.370
15i Duration of grounding for flight related neck pain	N=22	G=0.083 p=0.837	G=0.569 p=0.125	G=0.167 p=0.693	G=0.040 p=0.926	G=<0.001 p=1.000	G=0.171 p=0.621	G=0.380 p=0.136	G=0.433 p=0.104	G=-0.583 p=0.441

Table B-12.

Neck pain severity and non-anthropometric measures.

Question	Crew position	Age	Total flying hours	Flying hours last 28 days	Total NVG hours	NVG hours in last 28 days	NVG counterbalance weight
6iv Duration of neck pain no NVG during flight (all)	$\chi2$ (6,N=46) =6.395 p=0.380	G=-0.102 p=0.542 N=46	G=0.243 p=0.150 N=45	G=0.147 p=0.395 N=46			
6iv Duration of neck pain with NVG during flight	$\chi2$(12,N=53)=10.284 p=0.591	G=0.057 p=0.687 N=53	G=0.191 p=0.138 N=51	G=0.063 p=0.626 N=52	G=0.013 p=0.929 N=52	G=-0.158 p=0.263 N=52	G=0.073 p=0.678 N=37
7i Episodes of neck pain after flight	$\chi2$(6,N=47)=5.603 p=0.469	G=0.292 p=0.135	G=0.313 p=0.064	G=-0.125 p=0.482	G=-0.086 p=0.646	G=-0.179 p=0.320	G=0.092 p=0.716

		N=47	N=46	N=46	N=44	N=44	N=33
8 Severity of worst neck pain during flight	χ2(6,N=53)=4.033 p=0.672	G=0.083 p=0.632 N=53	G=0.146 p=0.348 N=52	G=0.176 p=0.255 N=52	G=0.142 p=0.382 N=50	G=0.117 p=0.494 N=51	G=0.000 p=1.000 N=35
8 Severity of worst neck pain after flight	χ2(6,N=49)=5.353 p=0.499	G=-0.070 p=0.670 N=49	G=0.054 p=0.748 N=48	G=0.003 p=0.985 N=48	G=-0.018 p=0.914 N=46	G=-0.031 p=0.867 N=46	G=-0.013 p=0.948 N=33
9 Severity of average neck pain during flight	χ2(4,N-46)=9.007 p=0.061	G—0.138 p=0.502 N=46	G=-0.099 p=0.621 N=45	G=0.323 p=0.060 N=45	G=0.172 p=0.335 N=44	G=0.063 p=0.744 N=44	**G=-0.533 p=0.015 N=30**
9 Severity of average neck pain after flight	χ2(4,N=44)=3.308 p=0.508	G=-0.243 p=0.206 N=44	G=0.222 p=0.250 N=43	G=0.290 p=0.126 N=43	G=0.288 p=0.096 N=41	G=0.191 p=0.320 N=41	G=-0.391 p=0.113 N=28
10 Duration of worst episode of neck pain	χ2(12,N=55)=6.036 p=0.914	G=0.069 p=0.171	G=0.192 p=0.156 N=54	G=0.037 p=0.760 N=54	G=0.137 p=0.295 N=51	G=0.076 p=0.538 N=51	G=0.092 p=0.604 N=36
11 Duration of average episode of neck pain	χ2(12,N=57)=10.351 p=0.585	G=0.012 p=0.936	G=0.155 p=0.197 N=56	G=0.142 p=0.190 N=56	G=0.080 p=0.565 N=53	G=0.143 p=0.224 N=53	G=0.000 p=1.000 N=38
15i Duration of grounding for neck pain	χ2(2,N=22)=2.703 p=0.259	G=0.188 p=0.572 N=22	G=0.169 p=0.578 N=22	G=0.528 p=0.102 N=22	G=-0.063 P=0.827 N=22	G=0.222 p=0.483 N=22	G=0.133 p=0.780 N=15

Back symptoms

Table B-13.
Back symptoms and anthropometric parameters

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
5i Back pain unrelated to flying	df=3 N=81	$\chi2$=2.563 p=0.464	$\chi2$=1.252 p=0.741	$\chi2$=3.902 p=0.272	$\chi2$=2.802 p=0.423	$\chi2$=3.767 p=0.288	$\chi2$=3.434 p=0.329	$\chi2$=2.036 p=0.565	$\chi2$=1.224 p=0.747	$\chi2$=3.006 p=0.391
5ii back pain related to flying (all)	df=3 N=81	$\chi2$=2.355 p=0.502	$\chi2$=4.174 p=0.243	$\chi2$=0.933 p=0.817	$\chi2$=0.664 p=0.882	$\chi2$=2.947 p=0.400	$\chi2$=0.272 p=0.965	$\chi2$=2.623 p=0.454	$\chi2$=0.362 p=0.948	$\chi2$=2.294 p=0.133
5ii back pain related to flying (pilot)	df=3 N=52	$\chi2$=2.212 p=0.530	$\chi2$=3.088 p=0.378	$\chi2$=0.239 p=0.971	$\chi2$=1.329 p=0.722	$\chi2$=1.132 p=0.769	$\chi2$=0.752 p=0.861	$\chi2$=3.488 p=0.322	$\chi2$=0.176 p=0.981	$\chi2$=5.119 p=0.163
5ii back pain related to flying (rear)	df=3 N=27	$\chi2$=0.920 p=0.820	**$\chi2$=10.758 p=0.013**	$\chi2$=1.688 p=0.640	$\chi2$=3.966 p=0.265	$\chi2$=1.800 p=0.615	$\chi2$=2.700 p=0.440	**$\chi2$=9.281 p=0.026**	$\chi2$=0.856 p=0.771	$\chi2$=0.270 p=1.000
6i Back pain during flight (all)	df=3 N=80	$\chi2$=3.412 p=0.332	$\chi2$=1.602 p=0.659	$\chi2$=0.729 p=0.866	$\chi2$=2.421 p=0.490	$\chi2$=1.081 p=0.782	$\chi2$=1.790 p=0.617	$\chi2$=2.488 p=0.478	$\chi2$=0.934 p=0.817	$\chi2$=4.556 p=0.207
6i Back pain during flight (pilot)	df=3 N=53	$\chi2$=1.996 p=0.573	$\chi2$=1.944 p=0.584	$\chi2$=1.407 p=0.704	$\chi2$=1.611 p=0.657	$\chi2$=0.557 p=0.906	$\chi2$=2.865 p=0.413	$\chi2$=1.850 p=0.604	$\chi2$=0.180 p=0.981	$\chi2$=4.484 p=0.214
6i Back pain during flight (rear)	df=3 N=26	$\chi2$=2.442 p=0.486	$\chi2$=2.735 p=0.434	$\chi2$=0.883 p=0.830	$\chi2$=5.918 p=0.116	$\chi2$=0.266 p=0.966	$\chi2$=0.735 p=0.865	$\chi2$=1.674 p=0.643	$\chi2$=2.345 p=0.504	$\chi2$=0.530 p=0.711 (df=1)

Table B-14.
Back symptoms and non-anthropometric parameters.

Question	Crew position	Age	Total flying hrs	Hrs last 28 days	Total NVG hrs	NVG hrs in last 28 days	NVG Counterbalance weight
5i Back pain unrelated to flying	$\chi2(2,N=81)=1.219$ p=0.544	G=0.275 p=0.069 N=81	G=-0.015 p=0.924 N=78	G=0.040 p=0.793 N=79	G=-0.037 p=0.827 N=69	G=0.051 p=0.761 N=69	G=0.043 p=0.839 N=50
5ii back pain related to flying (all)	$\chi2(2,N=81)=2.535$ p=0.282	G=0.353 p=0.126 N=81	G=0.431 p=0.054 N=78	G=0.260 p=0.157 N=79	**G=0.571 p=0.045 N=69**	G=0.107 p=0.716 N=69	G=0.159 p=0.611 N=49
6i Back pain during flight (all)	$\chi2(2,N=80)=4.302$ p=0.116	G=0.297 p=0.173 N=80	G=0.255 p=0.208 N=78	G=-0.044 p=0.806 N=79	G=0.358 p=0.108 N=68	G=0.064 p=0.809 N=68	G=0.341 p=0.227 N=49

Table B-15.
Contributory factors and anthropometry (back). Contribution of flight parameters and anthropometric measurements to back pain during flight.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
6ii Episodes of back pain during flight (all)	N=62	G=-0.77 p=0.658	G=0.227 p=0.224	G=0.158 p=0.373	G=0.104 p=0.573	G=-0.055 p=0.765	G=-0.013 p=0.939	G=0.108 p=0.511	G=0.159 p=0.380	G=0.286 p=0.356
6ii Episodes of back pain (front)	N=39	G=-0.045 p=0.384	G=0.201 p=0.343	G=0.038 p=0.863	G=0.224 p=0.302	G=0.119 p=0.612	G=-0.073 p=0.729	G=-0.118 p=0.560	G=0.020 p=0.930	G=0.430 p=0.173
6ii Episodes of back pain (rear)	N=23	G=-0.099 p=0.764	G=0.233 p=0.551	G=0.516 p=0.084	G=-0.130 p=0.692	G=-0.333 p=0.259	G=0.043 p=0.905	G=0.408 p=0.175	**G=0.515 p=0.051**	G=-1.000 p=0.137
6v low G (<2G) no NVG	df=6 N=61	$\chi2=1.798$ p=0.937	$\chi2=0.925$ p=0.988	$\chi2=4.031$ p=0.672	$\chi2=10.207$ p=0.116	$\chi2=2.697$ p=0.846	$\chi2=7.343$ p=0.290	$\chi2=10.770$ p=0.096	$\chi2=3.033$ p=0.805	$\chi2=5.547$ p=0.476

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
(all)										
6v low G with NVG (pilot)	df=6 N=39	χ2=3.687 p=0.719	χ2=3.314 p=0.769	χ2=8.556 p=0.200	χ2=11.503 p=0.074	χ2=2.956 p=0.814	χ2=7.371 p=0.288	χ2=7.924 p=0.244	χ2=3.709 p=0.716	χ2=6.464 p=0.373
6v low G (<2G) no NVG (rear)	df=6 N=22	χ2=9.469 p=0.149	χ2=2.200 p=0.699	χ2=2.994 p=0.810	χ2=6.554 p=0.364	χ2=10.263 p=0.114	χ2=3.919 p=0.688	**χ2=12.696 p=0.048**	χ2=9.423 p=0.454	χ2=0.825 p=0.662 (df=2)
6v low G (<2G) NVG (all)	df=6 N=59	χ2=5.379 p=0.496	χ2=5.108 p=0.530	χ2=6.422 p=0.378	χ2=3.968 p=0.681	χ2=3.706 p=0.716	χ2=8.877 p=0.181	χ2=6.669 p=0.353	χ2=1.822 p=0.935	χ2=10.183 p=0.117
6v low G with NVG (pilot)	df=6 N=38	χ2=4.853 p=0.563	χ2=2.976 p=0.812	χ2=6.337 p=0.387	χ2=7.923 p=0.244	χ2=5.979 p=0.426	χ2=7.955 p=0.241	χ2=8.094 p=0.231	χ2=4.006 p=0.676	χ2=9.567 p=0.144
6v low G with NVG (rear)	df=6 N=21	χ2=6.289 p=0.392	χ2=4.000 p=0.406	χ2=7.172 p=0.305	χ2=3.294 p=0.771	χ2=3.980 p=0.679	χ2=3.000 p=0.809	χ2=10.706 p=0.098	χ2=70.92 p=0.312	χ2=0.520 p=0.771 (df=2)
6v mod G (2-4G) no NVG (all)	df=6 N=51	χ2=7.458 p=0.281	χ2=3.902 p=0.690	χ2=7.463 p=0.280	χ2=3.042 p=0.804	χ2=4.704 p=0.582	χ2=6.754 p=0.344	χ2=3.268 p=0.774	χ2=1.659 p=0.948	χ2=0.965 p=0.915 (df=4)
6v mod G (2-4G) no NVG (pilot)	df=6 N=31	χ2=2.918 p=0.819	χ2=4.217 p=0.647	χ2=5.189 p=0.520	χ2=6.174 p=0.404	χ2=4.561 p=0.601	χ2=4.889 p=0.558	χ2=5.319 p=0.504	χ2=4.070 p=0.667	χ2=1.416 p=0.841 (df=4)
6v mod G (2-4G) no NVG (rear)	df=6 N=20	χ2=10.786 p=0.095	χ2=1.133 p=0.889	χ2=6.150 p=0.407	χ2=4.167 p=0.654	χ2=4.905 p=0.556	χ2=3.673 p=0.721	χ2=3.763 p=0.721	χ2=3.429 p=0.753	χ2=1.349 p=0.509 (df=2)
6v mod G with NVG (all)	df=6 N=53	χ2=7.781 p=0.255	χ2=5.746 p=0.452	χ2=10.091 p=0.121	χ2=5.250 p=0.512	χ2=3.163 p=0.788	χ2=6.736 p=0.346	χ2=4.652 p=0.589	χ2=1.683 p=0.946	χ2=6.571 p=0.160 (df=4)
6v mod G with NVG (pilot)	df=6 N=31	χ2=4.268 p=0.641	χ2=5.444 p=0.488	χ2=7.146 p=0.308	χ2=9.164 p=0.165	χ2=3.826 p=0.700	χ2=3.879 p=0.693	χ2=7.188 p=0.304	χ2=4.471 p=0.613	χ2=4.455 p=0.348 (df=4)
6v mod G with NVG (rear)	df=6 N=21	χ2=11.158 p=0.084	χ2=1.595 p=0.810	χ2=6.312 p=0.389	χ2=4.725 p=0.580	χ2=4.562 p=0.601	χ2=3.642 p=0.725	χ2=4.267 p=0.641	χ2=3.022 p=0.806	χ2=1.464 p=0.481 (df=2)
6v Posture no NVG (all)	df=6 N=63	χ2=9.908 p=0.129	χ2=6.585 p=0.361	χ2=3.303 p=0.770	χ2=4.006 p=0.676	χ2=3.977 p=0.680	χ2=3.076 p=0.799	χ2=2.499 p=0.869	χ2=4.833 p=0.565	χ2=1.056 p=0.901 (df=4)
6v Posture no	df=6	χ2=5.056	χ2=6.303	χ2=3.979	χ2=7.564	χ2=2.510	χ2=2.521	χ2=1.809	χ2=2.400	χ2=0.875

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
NVG (pilot)	N=39	p=0.537	p=0.390	p=0.680	p=0.272	p=0.867	p=0.866	p=0.936	p=0.879	p=0.928 (df=4)
6v Posture [1]no NVG (rear)	df=3 N=24	χ2=5.217 p=0.157	χ2=0.522 p=0.914	χ2=3.965 p=0.265	χ2=2.087 p=0.555	χ2=2.087 p=0.555	χ2=1.739 p=0.628	χ2=2.534 p=0.469	χ2=5.217 p=0.157	χ2=0.095 p=1.000 (df=1)
6v Posture with NVG (all)	df=6 N=61	χ2=2.999 p=0.809	χ2=5.707 p=0.457	χ2=2.525 p=0.866	χ2=8.415 p=0.209	χ2=2.472 p=0.872	χ2=4.928 p=0.553	χ2=4.943 p=0.551	χ2=5.180 p=0.521	**χ2=11.443 p=0.022 (df=4)**
6v Posture with NVG (pilot)	df=6 N=37	χ2=2.842 p=0.828	χ2=9.539 p=0.145	χ2=2.848 p=0.828	χ2=10.065 p=0.122	χ2=5.749 p=0.452	χ2=3.724 p=0.714	χ2=4.781 p=0.572	χ2=2.617 p=0.855	**χ2=13.313 p=0.010 (df=4)**
6v Posture with NVG (rear)	df=6 N=24	χ2=6.372 p=0.383	χ2=1.091 p=0.982	χ2=5.345 p=0.500	χ2=5.136 p=0.526	χ2=4.539 p=0.604	χ2=3.742 p=0.711	χ2=9.766 p=0.135	χ2=10.909 p=0.091	χ2=0.198 p=0.906 (df=2)

Table B-16.

Contributory factors and non-anthropometric measures (back). Influence of crew position, age and flying hours to back pain on reports of contributory factors to back pain during flight.

Question	Crew position	Age	Total flying hours	Flying hrs last 28 days	Total NVG hours	NVG hrs last 28 days	NVG Counterbalance weight
6ii Episodes of back pain during flight (all)	χ2(2,N=62)=1.896 p=0.388	G=0.132 p=0.506 N=62	G=0.254 p=0.164 N=61	G=0.220 p=0.168 N=62	G=-0.003 p=0.986 N=56	G=-0.082 p=0.667 N=56	G=0.142 p=0.555 N=38
6v low G (<2G) no NVG (all)	χ2(2,N=61)=2.344 p=0.310	χ2(6,N=54)=5.599 p=0.470	G=0.104 p=0.539 N=60	G=0.271 p=0.811 N=61	[redacted]		
6v low G	χ2(2,N=59)=4.575	χ2(6,N=0.112)=10.324	**G=0.367**	**G=0.390**	G=0.223	G=0.050	G=0.371

1 Posture without NVG, no rear crew responded not applicable, hence df=3

(<2G) NVG (all)	p=0.102	p=0.112	**p=0.030 N=58**	**p=0.013 N=59**	p=0.250 N=51	p=0.815 N=51	p=0.068 N=37
6v mod G (2-4G) no NVG (all)	χ2(2,N=51)=3.963 p=0.138	χ2(5,N=41)=2.276 p=0.810	G=-0.072 p=0.648 N=50	G=0.196 P=0.272 N=51			
6v mod G with NVG (all)	χ2(4,N=53)=5.286 p=0.259	χ2(6,N=39)=5.909 p=0.433	G=0.121 p=0.447 N=51	G=0.262 p=0.126 N=52	G=0.193 p=0.313 N=46	G=0.054 p=0.791 N=46	G=0.172 p=0.438 N=32
6v Posture no NVG (all)	χ2(2,N=63)=2.347 p=0.309	**χ2(5,N=61)=11.223 p=0.047**	G=0.211 p=0.427 N=62	G=0.271 p=0.200 N=63			
6v Posture with NVG (all)	χ2(2,N=61)=2.818 p=0.244	**χ2(5,N=54)=27.437 p=<0.001**	**G=0.741 p=0.003 N=60**	**G=0.604 p=0.002 N=61**	G=0.614 p=0.116 N=54	G=0.044 p=0.851 N=54	G=0.132 p=0.843 N=38

Table B-17.

Post-flight contributory factors and anthropometry (back). Contribution of flight parameters and anthropometric measurements to back pain after flying.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
7i Back pain after flight	df=3 N=80	χ2=3.209 p=0.361	χ2=3.788 p=0.285	χ2=5.092 p=0.165	χ2=0.446 p=0.930	χ2=3.410 p=0.333	χ2=1.088 p=0.780	χ2=0.729 p=0.866	χ2=0.555 p=0.907	χ2=0.617 p=0.735 (df=2)
7ii Back pain episodes after flight	N=64	G=-0.164 p=0.360	G=0.183 p=0.343	G=0.144 p=0.408	G=-0.119 p=0.539	G=-0.184 p=0.326	G=-0.066 p=0.691	G=-0.022 p=0.891	G=-0.149 p=0.373	G=0.405 p=0.177
7iv low G no NVG (all)	df=6 N=56	χ2=2.816 p=0.832	χ2=2.639 p=0.853	χ2=5.560 p=0.474	χ2=11.788 p=0.067	**χ2=15.306 p=0.018**	χ2=10.602 p=0.101	χ2=2.469 p=0.872	χ2=3.067 p=0.800	χ2=4.301 p=0.367 (df=4)
7ivlow G with NVG (all)	df=6 N=57	χ2=6.829 p=0.337	χ2=4.461 p=0.615	χ2=8.257 p=0.220	χ2=6.468 p=0.373	**χ2=15.746 p=0.015**	χ2=9.415 p=0.152	χ2=4.339 p=0.631	χ2=2.117 p=0.909	χ2=4.279 p=0.370 (df=4)

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circ	Neck circ
7iv Mod G no NVG (all)	df=6 N=51	χ2=3.729 p=0.731	χ2=5.391 p=0.495	χ2=6.776 p=0.747	χ2=10.437 p=0.107	χ2=6.795 p=0.340	χ2=8.008 p=0.238	χ2=3.731 p=0.713	χ2=1.180 p=0.978	χ2=2.737 p=0.603 (df=4)
7iv Mod G with NVG (all)	df=6 N=51	χ2=7.210 p=0.302	χ2=4.162 p=0.655	χ2=6.748 p=0.345	χ2=11.953 p=0.063	χ2=10.347 p=0.111	χ2=4.230 p=0.646	χ2=7.214 p=0.301	χ2=2.277 p=0.893	χ2=7.112 p=0.130 (df=4)
7iv Posture no NVG	df=6 N=62	χ2=9.441 p=0.150	χ2=7.938 p=0.243	χ2=5.922 p=0.432	χ2=2.305 p=0.890	χ2=6.407 p=0.379	χ2=5.237 p=0.514	χ2=9.600 p=0.143	χ2=2.667 p=0.849	χ2=3.603 p=0.462 (df=4)
7iv Posture with NVG	df=6 N=60	χ2=11.467 p=0.075	χ2=9.976 p=0.126	χ2=5.245 p=0.513	χ2=4.399 p=0.623	χ2=6.006 p=0.423	χ2=10.226 p=0.115	χ2=2.097 p=0.911	χ2=5.711 p=0.456	χ2=4.756 p=0.313 (df=4)

Table B-18.

Post-flight contributory factors and non-anthropometric parameters (back). Contribution of flight parameters and age, crew position and flying hours to back pain after flying.

Question	Crew position	Age	Total flying hours	Flying hrs last 28 days	Total NVG hours	NVG hrs last 28 days	NVG Counterbalance weight
7i back pain after flight	χ2(2,N=80)=2.855 p=0.240	**χ2(8,N=81)=19.702 p=0.012**	**G=0.527 p=0.014 N=77**	**G=0.390 p=0.034 N=78**	G=0.520 p=0.057 N=68	G=0.106 p=0.722 N=68	G=0.333 p=0.307 N=49
7ii Back episodes after flight	χ2(6,N=64)=7.325 p=0.292	G=0.348 p=0.054 N=65	G=0.190 p=0.292 N=62	G=0.001 p=0.995 N=63	G=0.076 p=0.672 N=58	G=0.047 p=0.790 N=59	G=-0.106 p=0.638 N=42
7iv Low G no NVG	χ2(2,N=56)=0.628 p=0.730	χ2(6,N=49)=6.240 p=0.397	G=0.221 p=0.177 N=55	**G=0.348 p=0.013 N=56**			
7iv Low G with NVG	χ2(2,N=57)=0.837 p=0.658	χ2(5,N=49)=2.263 p=0.812	**G=0.344 p=0.043**	**G=0.552 p=<0.001**	G=0.119 p=0.521	G=0.324 p=0.092	G=0.276 p=0.225

			N=56	**N=57**	N=51	N=51	N=37
7iv Mod G no NVG	χ2(2,N=51)=1.7689 p=0.413	χ2(5,N=40)=4.607 p=0.466	G=0.009 p=0.957 N=50	G=0.188 p=0.253 N=51			
7iv Mod G with NVG	χ2(2,N=51)=2.338 p=0.311	χ2(4,N=37)=1.284 p=0.864	G=0.190 p=0.235 N=50	**G=0.331 p=0.031 N=51**	G=0.268 p=0.114 N=45	G=0.211 p=0.246 N=45	G=0.187 p=0.402 N=31
7ivPosture no NVG	χ2(2,N=62)=0.886 p=0.648	χ2(5,N=58)=9.802 p=0.081	G=0.328 p=0.271 N=61	G=0.177 p=0.486 N=62			
7iv Posture with NVG	χ2(2,N=60)=0.776 p=0.679	χ2(4,N=53)=0.918 p=0.922	G=0.524 p=0.056 N=59	**G=0.499 p=0.011 N=60**	**G=0.889 p=0.033 N=54**	**G=0.260 p=0.429 N=54**	**G=-0.135 p=0.798 N=38**

Table B-19.

Anthropometric measurements and back pain severity.

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
6vi Duration of back pain no NVG (all)	N=66	G=-0.024 p=0.861	**G=-0.397 p=0.007**	G=0.098 p=0.467	G=-0.109 p=0.447	G=-0.085 p=0.518	G=-0.108 p=0.425	**G=-0.314 p=0.012**	G=-0.202 p=0.105	G=-0.183 p=0.398
6vi Duration of back pain with NVG (all)	N=60	G=-0.030 p=0.817	**G=-0.518 P=<0.001**	G=0.123 p=0.382	G=-0.087 p=0.560	G=-0.085 p=0.503	G=-0.138 p=0.296	**G=-0.247 p=0.047**	**G=-0.253 P=0.043**	G=-0.311 p=0.237
7ii back episodes after flight	N=64	G=-0.164 p=0.350	G=0.183 p=0.343	G=0.144 p=0.408	G=-0.119 p=0.539	G=-0.184 p=0.326	G=-0.066 p=0.691	G=-0.022 p=0.891	G=-0.149 p=0.373	G=0.405 p=0.177
11 Severity of worst back pain during flight (all)	N=71	G=-0.211 p=0.172	G=-0.046 p=0.786	G=-0.050 p=0.703	G=0.900 p=0.737	G=-0.099 p=0.510	G=-0.197 p=0.211	G=-0.122 p=0.420	G=-0.213 p=0.169	G=0.115 p=0.646
11 Severity of	N=72	G=-0.089	G=0.125	G=0.095	G=0.038	G=-0.50	G=0.028	G=0.023	G=-0.023	G=0.311

Question	df, N	Stature	Weight	Sitting height	Thumb tip reach	Functional leg length	Buttock knee length	Thigh clearance	Head circumference	Neck circumference
worst back pain after flying		p=0.511	p=0.419	p=0.480	p=0.782	p=0.713	p=0.826	p=0.243	p=0.871	p=0.173
12 Severity of average back pain during flight	N=69	G=-0.201 p=0.205	G=0.082 p=0.653	G=0.004 p=0.982	G=0.015 p=0.931	G=-0.235 p=0.157	G=-0.167 p=0.295	G=-0.102 p=0.522	G=-0.044 p=0.791	G=0.210 p=0.419
12 Severity of average back pain after flight (all)	N=71	G=-0.128 p=0.408	G=0.104 p=0.560	G=-0.056 p=0.694	G=0.022 p=0.891	G=-0.092 p=0.573	G=0.099 p=0.501	G=-0.050 p=0.747	G=-0.186 p=0.222	G=0.089 p=0.722
13i Duration of worst episode of back pain	N=73	G=-0.065 p=0.615	G=0.117 p=0.400	G=0069 p=0.600	G=0.014 p=0.917	G=-0.017 p=0.893	G=0.022 p=0.854	G=-0.041 p=0.726	G=-0.053 p=0.640	G=0.227 p=0.268
13ii Duration of average episode of back pain	N=73	G=0.139 p=0.309	G=0.016 p=0.913	G=0.133 p=0.303	G=0.099 p=0.454	G=0.149 p=0.247	G=0.109 p=0.354	G=0.023 p=0.859	G=-0.070 p=0.554	G=0.150 p=0.473
15iv Duration of grounding for flight related back pain	N=28	G=0.048 p=0.826	G=0.386 p=0.135	G=0.114 p=0.540	G=0.050 p=0.815	G=-0.114 p=0.611	G=0.278 p=0.214	**G=0.519 p=0.014**	G=0.258 p=0.233	G=-0.750 p=0.142

Table B-20.

Back pain severity and non-anthropometric measures.

Question	Crew position	Age	Total Flying hours	Flying hours in the last 28 days	Total NVG hours	NVG hours in last 28 days	NVG counterbalance weight
6iv Duration of back pain no NVG during flight (all)	χ2(6,N=66)=11.418 p=0.076	G=0.127 p=0.285 N=67	**G=0.282 p=0.023 N=65**	G—0.076 p=0.542 N=66			
6iv Duration of back pain with NVG during flight	χ2(12,N=60)=18.367 p=0.105	G=0.068 p=0.578 N=61	**G=0.355 p=0.005 N=59**	G=0.009 p=0.945 N=59	G=0.003 p=0.985 N=59	G=-0.094 p=0.481 N=59	G=0.022 p=0.902 N=41
11 Severity of worst back pain episode during flight	χ2(6,N=71)=10.417 p=0.108	G=0.120 p=0.202 N=72	G=0.255 p=0.076 N=69	G=0.252 p=0.069 N=70	G=0.255 p=0.057 N=65	G=0.147 p=0.306 N=65	G=-0.031 p=0.859 N=46
11 Severity of worst back pain after flight	χ2(6,N=72)=7.084 p=0.313	G=0.027 p=0.850 N=73	G=0.174 p=0.210 N=70	G=0.078 p=0.555 N=71	G=0.253 p=0.070 N=66	G=0.098 p=0.515 N=66	G=-0.008 p=0.964 N=47
12 Severity of average back pain during flight	χ2(6,N=69)=6.138 p=0.408	G=0.140 p=0.380 N=70	**G=0.383 p=0.009 N=67**	G=0.268 p=0.052 N=68	G=0.106 p=0.469 N=63	G=0.225 p=0.135 N=63	G=-0.217 p=0.196 N=44
12 Severity of average back pain after flight	χ2(4,N=71)=7.317 p=0.120	G=-0.027 p=0.853 N=72	**G=0.374 P=0.004 N=69**	G=0.182 p=0.159 N=70	G=0.238 p=0.112 N=65	G=0.182 p=0.252 N=65	G=-0.129 p=0.466 N=46
7ii Episodes of back pain after flight	χ2(6,N=64)=9.902 p=0.129	G=0.348 P=0.054 N=65	G=0.326 p=0.059 N=62	G=0.085 p=0.606 N=63	G=0.138 p=0.441 N=60	G=0.097 p=0.579 N=60	G=-0.113 p=0.590 N=43
7iii Duration of worst episode of back pain	χ2(10,N=73)=6.485 p=0.773	G=0.180 p=0.159 N=74	**G=0.481 p=<0.001 N=71**	G=0.118 p=0.325 N=72	**G=0.395 P=<0.001 N=66**	G=0.166 p=0.168 N=66	G=-0.058 p=0.715 N=47
Duration of average episode of back pain	χ2(10,N=73)=4.692 p=0.911	G=0.210 p=0.091 N=74	**G=0.449 p=<0.001 N=71**	**G=0.216 p=0.049 N=72**	**G=0.277 p=0.010 N=66**	G=0.214 p=0.062 N=66	G=-0.089 p=0.555 N=47
15iii Effect of back	χ2(4,N=83)=15.704	G=0.208	**G=0.349**	G=0.196	**G=0.529**	G=0.136	G=-0.228

Question	Crew position	Age	Total Flying hours	Flying hours in the last 28 days	Total NVG hours	NVG hours in last 28 days	NVG counterbalance weight
pain on mission related tasks	p=0.003	p=0.140 N=83	**p=0.003 N=80**	p=0.158 N=81	**p=<0.001 N=70**	p=0.336 N=70	p=0.242 N=49
15iv duration of grounding for back pain	χ2(5,N=28)=7.850 p=0.165	G=-0.014 p=0.944 N=28	G-0.029 p=0.865 N=28	G=0.328 p=0.115 N=28	**G=0.556 p=<0.001 N=28**	G=0.000 p=1.000 N=28	G=-0.181 p=0.445 N=20

Table B-21.

Influence of back pain severity on mission related tasks.

	Severity of worst back pain during flight	Severity of worst back pain after flight	Severity of average back pain during flight	Severity of average back pain after flight	Duration of worst back pain	Duration of average back pain
15iii Effect of back pain on mission related tasks	**G=0.570 N=70 p=0.001**	**G=0.612 N=71 p=<0.001**	**G=0.684 N=69, p=<0.001**	**G=0.531 N=70 p=0.003**	**G=0.632 N=72 p=<0.001**	**G=0.362 N=72 p=0.015**

Table B-22.

Factors influencing treatment of neck pain.

Question	Crew position	Age	Worst neck pain during flight	Worst neck pain after flight	Average neck pain during flight	Average neck pain after flight	Duration of worst neck pain	Duration of average neck pain
14i Sought treatment for neck pain	χ2(2,N=79)=0.645 p=0.724	χ2(8,N=80)=8.779 p=0.361	G=0.23 p=0.295 N=52	**G=0.418 p=0.042 N=48**	G=-0.148 p=0.587 N=45	G=0.254 p=0.346 N=43	**G=0.647 p=<0.001 N=54**	**G=0.623 p=<0.001 N=56**
14iii Treatment given for neck	χ2(2,N=32)=1.097 p=0.578	χ2(6,N=32)=5.193 p=0.519	G=-0.036 p=0.901	G=0.132 p=0.681	G=-0.019 p=0.959	G=-0.020 p=0.957	**G=0.726 p=<0.001**	**G=0.482 p=0.047**

pain			N=30	N=28	N=28	N=27	**N=30**	**N=30**
15i Grounded for flight-related neck pain	χ2(2,N=81)=1.951 p=0.377	χ2(8,N=82)=8.090 p=0.425	G=0.491 p=0.216 N=53	G=0.563 p=0.155 N=49	G=0.101 p=0.805 N=45	G=0.625 p=0.108 N=43	**G=0.661** **p=0.021** **N=55**	**G=0.709** **p=0.021** **N=57**
15iii Effect of neck pain on mission related tasks	χ2(4,N=76)=2.700 p=0.609	χ2(7,N=51)=4.655 p=0.702	**G=0.536** **p=0.013** **N=53**	**G=0.546** **p=0.003** **N=49**	**G=0.721** **P=0.004** **N=45**	**G=0.660** **p=0.017** **N=43**	**G=0.702** **p=<0.001** **N=55**	**G=0.537** **p=<0.001** **N=57**
15vii Action to minimize flight related neck pain	χ2(2,N=75)=1.490 p=0.475	χ2(8,N=76)=9.530 p=0.300	G=0.236 p=0.287 N=51	G=0.300 p=0.191 N=48	G=0.205 p=0.474 N=43	G=0.442 p=0.113 N=42	**G=0.722** **p=<0.001** **N=52**	**G=0.586** **p=<0.001** **N=54**
15viii Effect of neck pain on leisure activitiy	χ2(2,N=75)=0.848 p=0.654	χ2(8,N=76)=10.001 p=0.265	**G=0.628** **p=0.001** **N=48**	**G=0.602** **p=0.001** **N=45**	G=0.455 p=0.079 N=43	**G=0.500** **p=0.051** **N=41**	**G=0.710** **p=<0.001** **N=51**	**G=0.666** **p=<0.001** **N=53**

<u>Table B-23.</u>

Factors influencing treatment of back pain.

Question	Crew position	Age	Worst back pain during flight	Worst back pain after flight	Average back pain during flight	Average back pain after flight	Duration of worst back pain	Duration of average back pain
14i Sought treatment for back pain	χ2(2,N=84)=2.425 p=0.298	χ2(8,N=85)=12.865 p=0.117	**G=0.658** **P=<0.001** **N=71**	**G=0.720** **p=<0.001** **N=72**	**G=0.402** **P=0.041** **N=69**	**G=0.525** **p=0.004** **N=71**	**G=0.738** **p=<0.001** **N=73**	**G=0.543** **P=<0.001** **N=73**
14iii Treatment given for back pain	χ2(2,N=45)=0.769 p=0.681	χ2(6,N=45)=5.753 p=0.451	**G=0.544** **p=0.023** **N=44**	**G=9.232** **p=0.012** **N=45**	G=2.369 p=0.629 N=44	G=0.202 p=0.458 N=45	G=0.402 p=0.099 N=45	G=0.311 p=0.159 N=45
15iv Grounded for flight-related back pain	**χ2(2,N=83)=8.745** **p=0.013**	χ2(8,N=84)=5.922 p=0.656	**G=0.587** **p=0.005** **N=70**	**G=0.809** **P=<0.001** **N=71**	**G=0.515** **p=0.028** **N-68**	**G=0.675** **p=0.001** **N=70**	**G=0.795** **p=<0.001** **N=72**	**G=0.534** **P=0.002** **N=72**
15vi Effect of back pain on mission related tasks	**χ2(4,N=83)=15.704** **p=0.003**	χ2(6,N=64)=3.918 p=0.688	**G=0.570** **p=0.001** **N=70**	**G=0.612** **p=<0.001** **N=71**	**G=0.684** **p=<0.001** **N=69**	**G=0.531** **p=0.003** **N=70**	**G=0.632** **p=<0.001** **N=72**	**G=0.362** **p=0.015** **N=72**

Question	Crew position	Age	Worst back pain during flight	Worst back pain after flight	Average back pain during flight	Average back pain after flight	Duration of worst back pain	Duration of average back pain
15vii Action to minimize back pain	χ2(2,N=81)=0.737 p=0.692	χ2(8,N=82)=11.813 p=0.160	**G=0.509 p=0.006 N=70**	**G=0.430 p=0.013 N=71**	**G=0.584 p=0.003 N=69**	G=0.224 p=0.298 N=70	**G=0.569 p=<0.001 N=72**	**G=0.552 p=<0.001 N=72**
15viii Effect of back pain on leisure activity	**χ2(2,N=80)=7.479 p=0.024**	χ2(8,N=81)=13.292 p=0.102	**G=0.866 p=<0.001 N=68**	**G=0.895 p=<0.001 N=69**	**G=0.728 p=0.001 N=66**	**G=0.495 p=0.016 N=68**	**G=0.613 p=<0.001 N=70**	**G=0.580 p=<0.001 N=70**

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